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DUPUYTREN'S CONTRACTION

WITH A DESCRIPTION OF THE PALMAR FASCIA, A REVIEW OF THE LITERATURE, AND A REPORT OF TWENTY-NINE SURGICALLY TREATED CASES[1]

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GUILLAUME BARON DUPUYTREN, "whom living all admired, but whom few loved, and no one understood,"[2] was born October 5, 1777, or 1778 (his biographers disagree as to the year) at Pierre-Buffière, a small town of Haute Vienne, four leagues from Limoges. Napoleon and Wellington were eight years his senior, Beethoven seven, Turner two, Hokusai seventeen, Sir Astley Cooper nine.

In 1789 a cavalry officer stationed at Pierre-Buffière asked and received permission from Dupuytren's father, an advocate of limited means, to send the boy to school in Paris. There he studied for four years until the schools were closed in the turmoil associated with the Revolution, and for lack of funds the young student was compelled to return the two hundred miles to his home on foot.

To fulfill his father's wishes and because the years at the College of La Marche had aroused his ambition, he determined to return to Paris and study medicine. His ambition was achieved, but only at great self sacrifice. Often he was compelled to study in bed for lack of fuel for a fire. He used fat from cadavers to serve as oil for his light, and at one time he lived for more than six weeks on bread and cheese. It is said that but for the help of a friendly water carrier from Auvergne he would have starved during the earlier years of his medical education.

When scarcely 18 he was appointed prosector in anatomy in one of the schools established by Fourcroy and from that time fortune smiled on him. In 1801 he was made head of his department with the title of Chef des Travaux Anatomiques. Among his pupils during this period were Laennec and Cruveilhier—names that have also attained enduring fame. In 1804 he competed against Roux, Tartra, and others for the position of surgeon of the second class at the Hôtel Dieu and won the appointment. In 1808 he was again advanced; and in 1812 after a brilliant *concours*, in which Tartra, Roux, Marjolin, and Dupuytren were the contestants, he was appointed to the chair of operative medicine as successor to Sabatier. It is said by Malgaigne that his thesis on lithotomy, submitted to fulfill one of the requirements of the *concours*, was long regarded as a work of art and as a model of surgical and anatomical excellence which up to that time had not been equaled.

During the years preceding and immediately following this appointment an intense rivalry developed between Dupuytren and Pelletan,

[2] Memoir in the *Lancet*, 1835, i, 752.

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the surgeon-in-chief of the Hôtel Dieu. The former was a thorn in the flesh to his brilliant but indolent superior, and lost no opportunity of ridiculing the slipshod methods and inaccurate diagnoses of Pelletan before his students. Finally as a result of two unfortunate incidents Pelletan was superseded by his younger rival.[1]

Cruveilhier, one of Dupuytren's pupils, tells us of his methods and work at the Hôtel Dieu. He arose daily at five o'clock and began the morning round at six, and woe to the house surgeon or nurse who was not on duty at the appointed time. The first task of the day was to make the rounds of the wards, at which time he questioned and examined his patients with great care and thoroughness. To one of his house officers was assigned the sole duty of accurately recording the observations made on these occasions.

After the morning round he delivered a clinical lecture in the amphitheater of the hospital, usually to classes of three and four hundred. Operations,[2] the out-patient department, and postmortem examinations took up the remainder of the morning. The afternoon was devoted to his consulting practice which became very large as his prestige and popularity increased. It is said that during the later years of his life his private patients numbered ten thousand a year. In the evening he again made rounds at the hospital and frequently performed one or two operations at this time.

Needless to say, he was compelled to pay the price of maintaining so strenuous a pace, without thought of rest or relaxation, year in and year out. One morning at the close of 1833 while on his way to the hospital he suffered a slight stroke of apoplexy. He went through his ordinary routine, but on his return home was immediately bled. On recovering from this attack he made a tour of Italy—his first vacation; but he was unhappy and restless, anxious to resume his work. On his return he attempted to assume his regular activities but finally, because of his increasing disability, he was compelled to relinquish his place at the hospital. During the succeeding months he developed a chronic pleuritis which gradually led to a fatal termination February 8, 1835.

Of Dupuytren's ability as a surgeon and teacher there can be little doubt. His biographers unite in considering him the first surgeon of his time and the founder of clinical surgery in France. No field of surgery that he touched but was enriched by his skill and ingenuity. He first demonstrated the nature of yellow elastic and erectile tissue; he proved by animal experimentation that excision of the spleen could be performed with safety; he pointed out the fact that iliac abscess on the right side was frequently due to perforation of the vermiform appendix; he showed that chronic enlargement of the testis was often due to lues and could be cured by "Dupuytren's pill," a mercuric preparation; he introduced greatly improved methods of treating fractures, particularly fractures of the femoral neck and lower end of the fibula; he was the first to excise a carcinomatous cervix, the first to describe congenital dislocation of the hip; he reformed the treatment of urethral stricture by introducing the method of gradual dilatation with flexible bougies. He was particularly interested in the treatment of lachrymal fistula and cataract. His treatment of the latter, however, by couching was not in accord with the best practice of his time, and because of it he was bitterly criticized. Today his name is particularly associated with idio-

[1] The first of these was an ill-advised operation for a massive malignant growth of the shoulder and arm, for which in a joint consultation Pelletan had advised operation, but which Dupuytren had insisted should not be operated upon. In spite of Dupuytren's counsel Pelletan operated upon the patient without advising his colleagues and the patient died immediately afterward. The second incident is described by Lisfranc who was assisting Pelletan. A Russian officer who had developed a massive swelling of the groin following a gunshot wound of the thigh was operated upon by Pelletan. Following the incision, made for drainage of what had been diagnosed as a deep abscess below Poupart's ligament, a stream of blood gushed from the wound. The hæmorrhage was quickly checked by Lisfranc who, in accordance with Dupuytren's teaching, applied pressure over the iliac vessels. Pelletan, who did not understand the technique of ligating large blood vessels, made two parallel incisions above Poupart's ligament, passed a needle deeply into the tissues and ligated the structures between the incisions *en masse*. He then ordered Lisfranc to release the pressure, and again blood poured from the wound. Packing was introduced as quickly as possible but the unfortunate patient expired before the bleeding could be checked. An investigation by a commission of Russian officers was made, and as a result Pelletan was superseded by Dupuytren as surgeon-in-chief.

[2] During this period there were five surgical wards at the Hôtel Dieu out of a total of fifteen, with 264 beds, 191 for men and 73 for women. Of these Dupuytren gave 151 to his assistants and reserved 113 for his own service. Approximately 1,400 surgical cases were cared for each year.

Some idea of the amount and type of work performed may be gained from a summary of the work of one year—1818. During these twelve months Dupuytren performed 368 surgical operations, set 178 fractures, and opened 300 abscesses. Included in the first group were 16 cases of fistula *in ano*, 60 of cataract, 4 of lachrymal fistula, 44 of strangulated hernia, 7 of urinary calculi, 9 of hydrocele, 6 of cancer of the lower lip, 17 of cancer of the breast, 3 in which an artificial anus was established, 1 amputation of the upper jaw, 1 of the lower jaw, 10 of the thigh, 2 of the leg, 2 of the arm, and 1 of the forearm.

pathic contraction of the palmar fascia,[1] with fractures about the ankle, and with the classification of burns which he suggested. As a teacher Dupuytren's reputation was such that his classes constantly numbered three and four hundred; one writer says that audiences of five hundred in the amphitheater of the Hôtel Dieu were not uncommon. His biographers have vividly described him as he appeared before his classes—always dressed in the same round-cut, green coat and white apron, the brim of his green casquette turned back from his forehead and his left hand applied to his mouth; for rarely, no matter in what company, did he cease gnawing the nails of his thumb and index finger. He was not distinguished for his eloquence but possessed the ability to present a subject clearly and forcefully, and to illustrate it with a wealth of detail and of examples observed during the many years of his service at this, the largest of French hospitals. He wrote little; our knowledge of his achievements and teaching is gathered chiefly from the reports of his lectures, the *Leçons Orales*, edited by his pupils Pierre de Boisement and Marx.

His relations with his contemporaries and associates were unfortunate. A few of them have written of him kindly and admiringly; the majority seem to agree with Lisfranc who dubbed him "The Brigand of the Hôtel Dieu." His despotic, arrogant nature, which brooked no contradiction, his jealousy of his contemporaries which led him constantly to seek provincial appointments for potential rivals, his failure to acknowledge the ability or the achievements of others, his almost brutal lack of consideration for the patients entrusted to his care, are blots on his memory which one would like to efface. One is glad to read that hundreds of the working men of Paris followed his body to his grave as a tribute to his services to them and their fellows.

His home life was unhappy; his wife left him because of a scandal; his one passion was his daughter, whom he idolized and to whom he left the greater part of his fortune of more than three million francs, gained through his unaided efforts in the practice of surgery.

Of public honors he reaped a generous share. To have been chief surgeon and dictator of the only large hospital in Paris for twenty years was in itself sufficient to have made his name famous. In 1818 he was elected a member of the Institute. He had been a member of the Academy of Medicine from its foundation and its president in 1824. In 1820 Louis XVIII conferred a baronetcy on him, and he was surgeon in turn to Louis XVIII and Charles X. During the reign of the latter he was elected to the Academy of Sciences. In spite of all "he was through life absorbed in his professional work; he had no other interests, no politics, no religion, and no friend except his daughter." He died as he lived, a "stern, melancholy, ambitious and bitter man . . . difficult to idealize except as a martyr to his work" (Hutchinson).

[1] Concerning the controversial question of priority and Dupuytren's contraction Keen says: "Henry Cline, at least as early as 1808, in his lectures alluded to its real character; Sir Astley Cooper also had done the same and even had advocated the subcutaneous method of operating; but nobody paid any attention to them. Dupuytren first compelled a hearing. How emphatically he impressed his views on the profession is shown in the number of theses and other papers that soon followed, and his 'marchand du vin en gros' and his 'cocher d'environ quarante ans' reappear as familiar friends in nearly every one" and, "It was reserved for Dupuytren in 1831 to proclaim the important fact, based on the dissection of a case . . ." that the condition was due solely to a contraction of the fascia of the hand and not to an involvement of the flexor tendons.

Hutchinson says: "Whether Sir Astley Cooper first suggested the right explanation of this condition (as asserted by one French writer) or not is quite immaterial. But it may remind us of the fact that Dupuytren, though he never visited England, was a friend of Cooper, and that his writings are full of references to his works and those of other English surgeons."

SINCE 1832, when Dupuytren first described the contraction of the palmar fascia to which succeeding generations have given his name, this condition has aroused widespread speculation and interest. Its insidious onset, usually without apparent cause, its progressive character, its predilection for the ulnar side of the hand, its tendency to appear in the male members of successive generations, and the frequent failures resulting from attempts at surgical treatment have combined to give it a distinctive place among the pathological conditions that affect the hand and forearm.

During the past twelve years we have had under our care 29 patients with contraction of the palmar fascia. We wish to add this group to those already reported, to record the

observations made in a study of the palmar fascia both of the normal and of the contracted hand, and to describe the surgical treatment employed for the relief of such contractions and the results of this treatment with cases under our care.

THE PALMAR FASCIA

Cunningham describes the palmar aponeurosis as a "thick triangular membrane, the apex of which joins the distal edge of the transverse carpal ligament, and more superficially receives the insertion of the tendon of the palmaris longus muscle. The fascia separates below into four slips, one for each finger, connected by transverse fibers, and forming beneath the webs of the fingers the superficial transverse metacarpal ligament (fasciculi transversi). Beyond this each slip separates into two parts, to be connected to the sides of the metacarpophalangeal joints and the first phalanx of the medial four digits. . . . The lateral borders of the triangular central portion of the palmar aponeurosis are continuous with thin layers of deep fascia which cover and envelop the muscles of the thenar and hypothenar eminences."

Spalteholtz says: "The palmar aponeurosis lies in the palm directly under the skin and is intimately united with it by short fibers. It is triangular and consists of two layers. Its superficial longitudinal fibers are the expansion of the tendon of the palmaris longus and pass in five diverging bands chiefly to the skin of the fingers at the level of the heads of the metacarpal bones. The deep layer with its transverse fibers is the continuation of the fibers of the transverse carpal ligament. Near the free edge of the webs of the fingers sharply demarcated bands, the fasciculi transversi, which are in part united with one another, pass from the second to the fifth finger directly under the skin.

"From the deep layer sagittal septa, which separate the canal-like spaces for the flexor tendons and for the blood vessels and nerves from one another, pass deeply to the metacarpal bones. They are united distally with the vaginal ligaments. The thenar and hypothenar eminences are covered only with thinner fascia."

These concise descriptions of the palmar aponeurosis leave unmentioned the remaining portions of the fascia of the hand of which the aponeurosis is only one, though an important part. In reality the palmar aponeurosis is part of a complicated structure which forms a fibrous tissue investment for the entire hand, and which is divided into superficial palmar, deep palmar or volar interosseous, digital, and dorsal portions.[1] Since the superficial palmar fascia is developed in such a striking fashion the remainder of the fascia of the hand has received little attention, and many observers, therefore, have been puzzled to account for some of the phenomena found in Dupuytren's contraction since the contracting bands and cords often failed to correspond with the normal position of the palmar fascia.[2]

In order, therefore, to obtain a more accurate and comprehensive conception of the fascia of the hand, through the co-operation of the Department of Anatomy of the Northwestern University Medical School, a careful study was made of a number of hands from the dissecting room, and of section of hands cut at different levels and in different planes. Every effort was made to correlate the information so obtained with the findings and

[1] The fascia of the hand is not only of anatomic interest. It has several specific functions in addition to those of maintaining contour and giving support—functions characteristic of fascia throughout the body. By its fibrous superficial palmar portion it protects from injury the underlying digital nerves and blood vessels, the tendons and tendon sheaths and the small muscles of the hand. By its attachment to the skin superficially, and more deeply to the fascial covering of the small muscles of the hand, the metacarpal bones and phalanges of the fingers, it holds the soft parts in a constant relation to the bony framework of the hand throughout its many complicated movements. The fibrous tendon sheaths of the flexor tendons and the fasciculi transversi (the natatory ligaments or fibers of Gerdy), which form the fibrous framework for the webs of the fingers, are especially well developed parts of the superficial palmar fascia of particular importance in carrying out this function. When traction is exerted upon the superficial portion by contraction of the palmaris longus, it adducts the fingers toward the mid-line of the hand and helps to flex the fingers at the metacarpophalangeal joints. With the interdigital septa which pass from the superficial palmar to the volar interosseous layer it forms the fascial spaces of the hand which assume particular importance in the presence of spreading infection. On the dorsum of the hand it helps to unite the extensor tendons into a single aponeurotic layer.

[2] Dupuytren in 1832 in his *Leçons Orales* described the palmar aponeurosis, and noted particularly the bifurcation of the fascial bands at the bases of the proximal phalanges and their attachment to the sides of the fingers. Bourgery and Jacob (1844), Sevestre (1867), Keen (1882), Grapow (1887), Poirier and Charpy (1901), and Frohse (1906) also made careful studies of the palmar fascia, and have given us the most accurate description available at the present time.

Frohse described the digital portion of the palmar aponeurosis as well as oblique fibers running from the index finger to the thumb independent of the fasciculi transversi. He emphasized the attachment of the fasciculi transversi to the skin of the fingers and the aponeurotic character of the deeper layer of the digital covering. He pointed out, as had Keen, the continuity between the palmar fascia and the digital fascia. He did not describe the fascial sheets in the fingers between which the digital arteries and nerves pass to their distribution.

Poirier and Charpy's description is particularly complete and has been translated into German by Frohse and Fraenkel for Bardeleben's *Handbuch*.

variations noted in contracted hands at operation. The following description of the fascia of the hand is based upon these studies.

For descriptive purposes the fascia of the hand may be divided into four parts: the superficial palmar fascia, the volar interosseous fascia, the dorsal fascia, and the digital fascia. Various septa, fibers, and ligaments help to unite these layers and bind them into a compact whole. Some of these because of their prominence have received definite descriptive names; others have frequently been overlooked or at least unmentioned.

The superficial palmar fascia (Fig. 1), as noted above, is accurately described as the palmar aponeurosis in most textbooks of anatomy. Its origin from the palmaris longus or, in the absence of the latter, from the antibrachial fascia, its triangular shape, its shiny glistening appearance, its superficial, longitudinal, and deeper transverse fibers, its division

Fig. 1. The superficial palmar fascia (palmar aponeurosis).

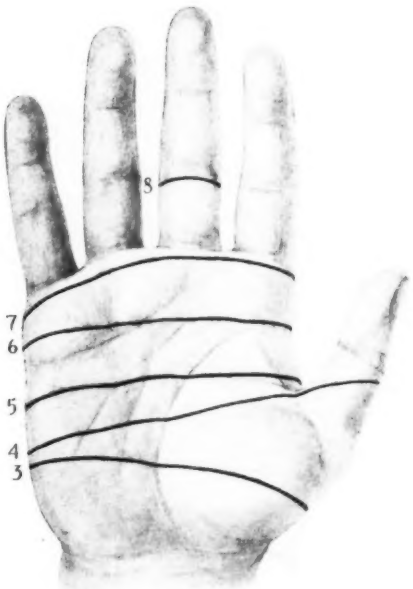


Fig. 2. Diagram indicating the levels of the sections illustrated in Figures 3–8.

into four distinct longitudinal bands (the pretendinous bands or *longuettes pretendineuses* of Poirier), inserted chiefly into the deep layers of the skin just proximal to the webs of the fingers, and a fifth less distinct band inserted into the skin of the first interosseous space (Fig. 1), its thinner lateral portions which cover the thenar and hypothenar eminences and the marked development of its transverse fibers at the webs of the fingers are well recognized features. Its intimate relation to the transverse carpal ligament (Fig. 3), and the many short vertical and oblique fibers, arranged in fairly definite longitudinal lines, which unite the fascia to the deeper layers of the skin (Figs. 3, 4) have been described by a number of observers, but are usually unmentioned in textbooks of anatomy. The latter are of particular interest for through this attachment between the palmar aponeurosis and the skin is produced the dimpling of the palmar skin which is frequently the first sign of Dupuytren's contraction. The thin fascial layer which covers the interdigital spaces and overlies the digital nerves and

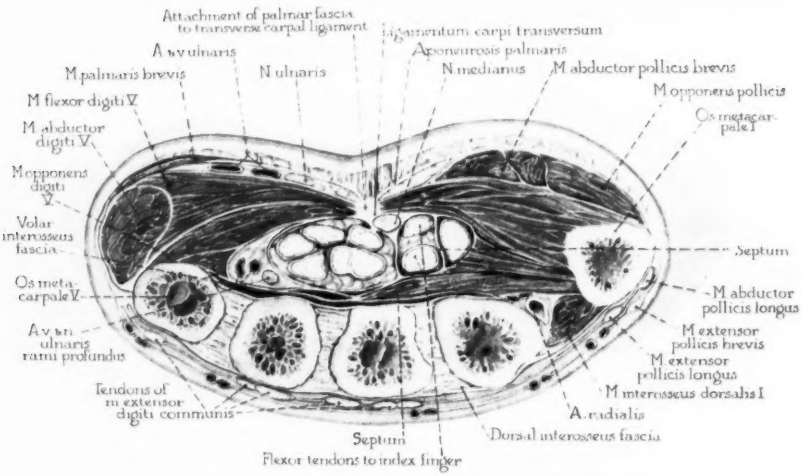


Fig. 3. Cross section of the hand one inch below the wrist joint.

vessels as they become more superficial is the direct continuation of the central portion of the palmar aponeurosis, but because of its tenuous character is usually unnoticed.

Of equal importance from a surgical standpoint with the superficial palmar fascia are the volar interosseous fascia, the digital fascia and the septa which unite them. The volar interosseous fascia (Figs. 3, 4, 5), as its name indicates, covers the hollow cup of the palm which is left after the removal of the flexor tendons, the digital nerves, and the palmar arches. It is continuous with the fascia covering the pronator quadratus; it covers the palmar interossei and is attached to the carpal and metacarpal bones. At the heads of the metacarpal bones, its transverse fibers are strengthened and interdigitate with one another to form the transverse metacarpal ligament (*lig. capitulorum transversum*) (Figs. 6, 9). Distally it blends with the deep layer of the fibrous sheath of the flexor tendons (Figs. 6, 9).

Three important longitudinal septa unite the superficial palmar fascia with the volar interosseous fascia. The medial septum, attached deeply to the transverse carpal ligament above and to the fifth metacarpal bone more distally, separates the flexor tunnel from the muscles of the hypothenar eminence (Figs. 4, 5), and is pierced by the superficial branches of the ulnar nerve and artery as they pass into the middle compartment of the palm. The lateral septum, attached deeply to the first and second metacarpal bones lateral to the flexor tendons of the index finger, separates the flexor tunnel and its contents from the muscles of the thenar eminence (Figs. 4, 5). The middle septum passing deeply between the flexor tendons of the index and middle fingers to the middle metacarpal bone, divides the space between the medial and lateral septa into two definite fascial compartments—the middle palmar space and thenar space (Figs. 4, 5). As it passes in front of the flexor tendons of the index finger, it forms the roof of the thenar space. Other more tenuous longitudinal septa form the lateral walls of the individual tunnels in which the flexor tendons lie. At first the adjacent septa which cover adjacent tendons lie in close apposition as do the tendons which they cover. As the tendons diverge the septa become separated from one another so as to leave narrow V-shaped spaces in which run the digital nerves and arteries and lumbrical muscles (Fig. 6), each covered by a thin layer of fascia which they derive as they pierce the fascial covering of the flexor tendons which they accompany higher in the palm.

As the septa which form the lateral walls of the flexor tunnels separate from one another,

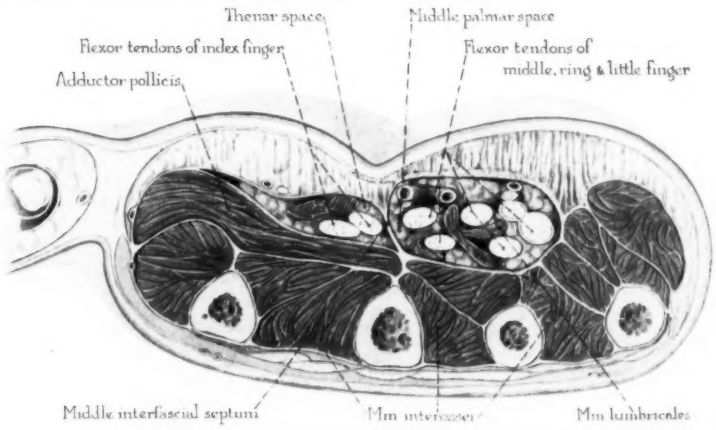


Fig. 4. Cross section of the hand at the level of the abducted thumb. (The proximal surface of the section is shown, instead of the distal surface, as in Figure 3, and Figures 5–9.)

they increase in thickness and distally gain an attachment to the transverse metacarpal ligament, the capsule of the metacarpophalangeal joints and the lateral aspects of the proximal phalanges. By means of oblique fibers passing superficial to the flexor tendon sheaths they gain an attachment to the opposite sides of the proximal phalanges as well, and help to form the deep layer of the digital fascia. Through the contraction of these fibers the digital nerves and blood vessels may be displaced from one side of the finger to the other (Fig. 10), and fingers not primarily involved in the contraction flexed and partially rotated from a normal position.

The superficial layer of the digital fascia (Figs. 7, 8) is the direct continuation of those fibers of the palmar aponeurosis which are not inserted into the skin, and of the fasciculi transversi or natatory ligaments mentioned above (Fig. 1). The deeper layer (Figs. 7, 8), which to the best of our knowledge has not heretofore been recognized as a definite structure, is the continuation of the paratendinous septa, mentioned above, which have gained an attachment to the capsule of the metacarpophalangeal joints, to the sides of the proximal phalanges, and by oblique fibers passing superficial to the flexor tendon sheaths, to the opposite sides of their respective phalanges and to the fibrous expansion of the extensor tendon. The digital nerves and blood vessels lie between the superficial and deep layers.[1]

That these are not artificial distinctions may be demonstrated by making a median incision along the palmar surface of the finger down to the tendon sheath and reflecting the superficial tissues to either side. In every instance the digital nerves and vessels will be found to be reflected with the fascial layers. If, on the other hand, a lateral incision is made only deep enough to expose the digital nerves and vessels, the fascial layer superficial to these structures may be followed to the opposite side of the finger and seen to be distinct from the deep layer which lies between them and the tendon sheath.

At the sides of the finger the superficial layer of the digital fascia is continuous with the superficial dorsal fascia. The deep layer is attached to the bone close to the attachment of the vaginal sheath and the aponeurotic expansion of the extensor tendon, and the insertion of the interosseous and lumbrical muscles.

[1] Although the digital nerves and blood vessels seem to have no fascia covering at the interdigital clefts just proximal to the web of the fingers (Fig. 1) careful dissection shows that they are covered by a thin fascial sheet which is continuous with the palmar aponeurosis above, with the fasciculi transversi below, and with the superficial layer of the digital fascia more distally.

As the tendons for the different fingers separate from one another in the palm the digital nerves and vessels, which at first accompany the tendons, pierce the paratendinous septa and come to lie in the V-shaped spaces between the tendons. They lie, therefore, outside of, or superficial to, the fascial layer which more distally is continuous with the deep layer of the digital fascia.

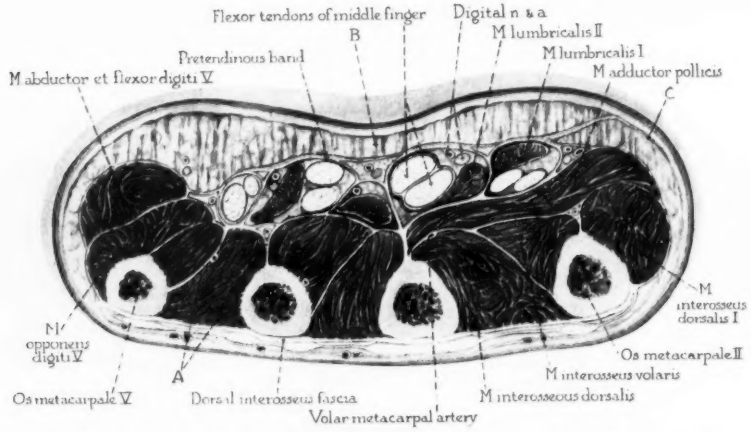


Fig. 5. Cross section of the hand midway between the wrist and the web of the fingers.

The flexion of the fingers that develops as the contraction of the palmar fascia progresses is due chiefly to the continuity of the superficial layer of the digital fascia with the longitudinal fibers of the palmar aponeurosis. The not infrequent deviation of the digital nerves and vessels from one side of the finger to the other results from the fact that they lie in a fibrous tunnel whose contracting walls are continually drawn proximalward toward the site of the primary involvement.

The dorsal fascia, as has been pointed out by Frohse and Fraenkel, consists of superficial, intermediate, and deep layers. The superficial layer (Figs. 5–8), covers the nerves and blood vessels and can be traced distalward on the fingers as a thin sheet superficial to the extensor tendons. The intermediate layer binds the extensor tendons into a single aponeurotic layer, and may represent, as has been suggested, a dorsal tendinous plate or aponeurosis in which the tendons have later become differentiated. This layer may be followed to the metacarpophalangeal joints where it gains a firm attachment to the heads of the metacarpal bones (Fig. 6). The expansion of the extensor tendons on the dorsum of the fingers is the digital continuation of this layer (Figs. 7, 8). The deep layer of the dorsal fascia (Figs. 3, 5) covers the interosseous muscles and ends distally at the metacarpophalangeal joints.

PATHOLOGY

The essential change found in Dupuytren's contraction is a hypertrophy and contraction of the fascia of the hand. As the process advances the overlying skin becomes involved. Rarely, if the contraction has persisted a number of years, there are changes in the conformation of the bony surfaces, particularly at the proximal interphalangeal joint, because of the long-continued immobilization in acute flexion.

As a rule the process begins in the fascia of the palm as an isolated nodular thickening, most frequently over the flexor tendons of the ring finger (Fig. 11). As the disease progresses, other nodules may appear in line with the first, or similar nodules may appear over the flexor tendons of the little finger, the middle finger, and the index finger in their order of frequency. The process may remain stationary for a number of months, but usually it progresses. A small pitlike depression develops just distal to the primary nodule and the skin is drawn upward in a crescentic fold, with the convexity of the crescent upward (Fig. 12). After an interval which varies from a few months in some cases to ten or fifteen years in others, the finger in line with the affected fascial fibers is gradually drawn into a flexed position through the contraction of the thickened cord which has replaced what was once a thin fascial band. As a rule flexion

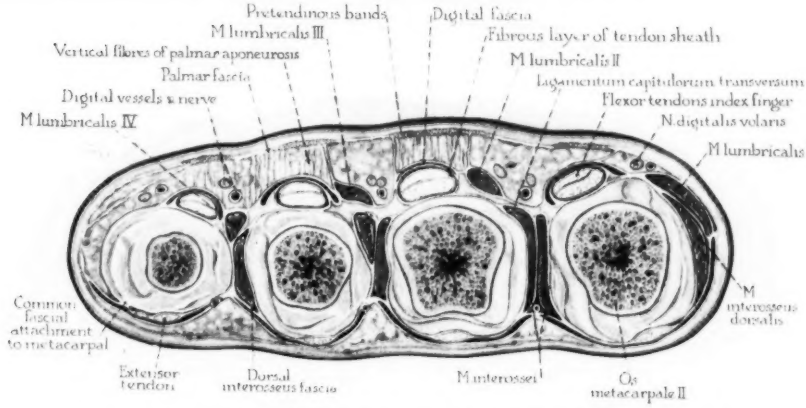


Fig. 6. Cross section of the hand at the level of the metacarpophalangeal joints.

takes place at the metacarpophalangeal and proximal interphalangeal joints while the distal joint is held in extension (Figs. 13–16). Eventually the tip of the finger may come to lie upon or even press into the surface of the palm (Figs. 16, 21). As flexion increases the subcutaneous cord stands out more prominently from the surrounding tissues and becomes closely adherent to the thickened, calloused overlying skin (Figs. 17, 18). Eventually the thickened skin loses all its normal characteristics and becomes so intimately united with the fascial cord that it is impossible to separate them (Fig. 18). At times the adjacent normal skin is drawn away from the palm in a web-like formation through which the thick fascial cord may be palpated as a taut bowstring (Fig. 19).

In some cases one finger only is involved, most commonly the ring finger, or the little finger, and the process remains limited to the finger in question. In other cases both the ring finger and little finger may be involved. Less frequently other fingers are affected either alone or in conjunction with others (Table IV).

Either hand, or both, may be affected (Table III). If both are affected the involvement of the one usually precedes that of the other by several months or years.

A careful dissection of a hand involved in such a contraction shows, as was first pointed out by Dupuytren, and later by Sevestre, Lane, Schulthess and other investigators who were fortunate enough to secure specimens of such hands for dissection, that only the fascia and the overlying skin are involved in the contraction; the flexor tendons and their sheaths remain quite normal, and the joint surfaces of the metacarpal bones and the phalanges show pressure changes only in rare instances. That the fascial involvement, however, is not limited to the superficial palmar fascia or aponeurosis has not been sufficiently emphasized. Thickening and contraction of the interfascial septa which unite the superficial palmar fascia with the volar interosseous fascia are not infrequently found and occasionally thickening of the dorsal fascia, manifesting itself in the formation of nodules on the dorsum of the fingers, is seen (Fig. 21).[1]

Since the degree of involvement may be greater on one side of the finger than on the other, lateral deviation of the finger may take place; and through involvement of the fasciculi transversi contraction of a finger adjacent to the one primarily involved may be marked.[2] Not only are adjacent fingers involved in this fashion but other structures of the hand, notably the digital nerves and blood vessels, may be compressed or may be dis-

[1] French mentions the occurrence of nodules on the dorsal aspect of the interphalangeal joints with the illustration of such a case from W. Hale White's paper in the *Quarterly Journal of Medicine*.

[2] Anderson called attention to the numerous variations in the position of the contracting bands. Figure 20 is taken from his monograph *Contractions of the Fingers and Toes*.

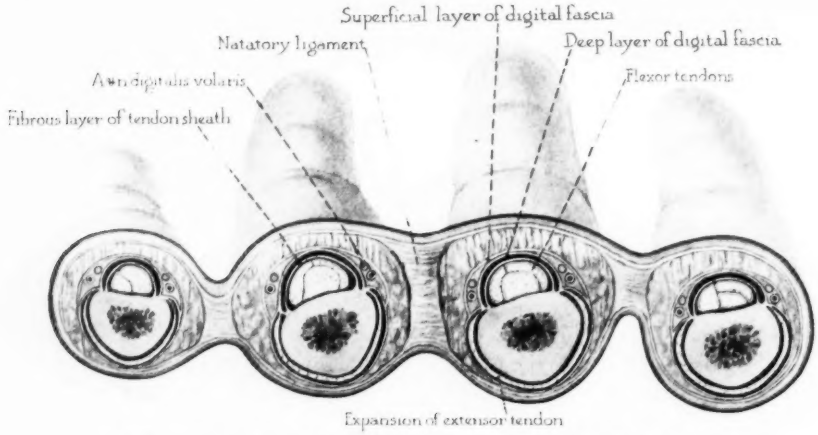

Superficial layer of digital fascia
Natatory ligament
Deep layer of digital fascia
A. et n. digitalis volaris
Flexor tendons
Fibrous layer of tendon sheath
Expansion of extensor tendon

Fig. 7. Cross section of the hand just proximal to the web of the fingers.

placed from their normal position. Displacement of a digital nerve the width of an entire finger was noted in one of our cases.

Microscopic examination of the skin and subcutaneous tissue in a well developed case of contraction shows a marked thickening of the corneal layer of the epidermis, a flattening of the deeper layers of the epidermis, gradual disappearance of the papillæ of the corium and substitution of thick fibrous tissue for the normal reticular layer of the corium, from which the fat and glands eventually disappear completely and in which the blood vessels are very markedly diminished (Figs. 22–25).

Microscopic examination under higher power of the fibrous tissue which has replaced the normal reticular layer of the corium shows masses of connective tissue cells with occasional areas of round cell infiltration (Fig. 26).[1] Occasionally, nerve fibers may be seen running through masses of connective tissue, but there is no evidence to show that the nerve fibers have any part in the fibrous tissue formation (Fig. 27).[2]

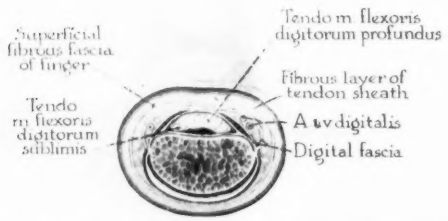

Superficial fibrous fascia of finger
Tendo m. flexoris digitorum profundus
Fibrous layer of tendon sheath
Tendo m. flexoris digitorum sublimis
A. et v. digitalis
Digital fascia

Fig. 8. Cross section of the middle finger just proximal to the proximal interphalangeal joint.

Occasionally, when separating a digital nerve from the fibrous tissue which surrounds it, one may see tiny, millet seed sized nodules lying along the course of the nerve and attached to it by tiny fibrils, as peas are attached to the pod. These are the Pacinian corpuscles and not pathological structures.

Although it is said that the plantar fascia may frequently show changes similar to those found in the palmar fascia in Dupuytren's contraction[3] in only two of our cases was there involvement of the feet (Fig. 15, f). In a third patient, who entered Wesley Memorial Hospital on the service of Dr. M. T. Goldstine because of a carcinoma of the cervix, there was a typical bilateral involvement of the hands and a marked cord-like thickening in the subcutaneous tissue of the soles of the feet

[1] The presence of areas of round cell infiltration, as seen in Figure 26, b, c, seemed to some observers to confirm the idea that Dupuytren's contraction is the result of an inflammatory process secondary to a low-grade infection. Experienced pathologists, however, have stated that the degree of round cell infiltration present is no greater than that seen in fibrous tissue formation in which infection has played no part.

[2] Coenen reported a case in which a plastic indurated proliferation of the connective tissue, amounting to a strand-like hardening of the fascia in the course of the ring and little fingers, followed a button hole perforation of the ulnar nerve, and suggested that ulnar nerve injury may be an etiological factor in the development of Dupuytren's contraction.

[3] Wm. Anderson, Amat, Madelung, Silva and Spechlin and Stoeber reported cases with involvement of the feet as well as the hands, and Lachelle, Baruk and Douady a similar case in which there was an associated scleroderma.

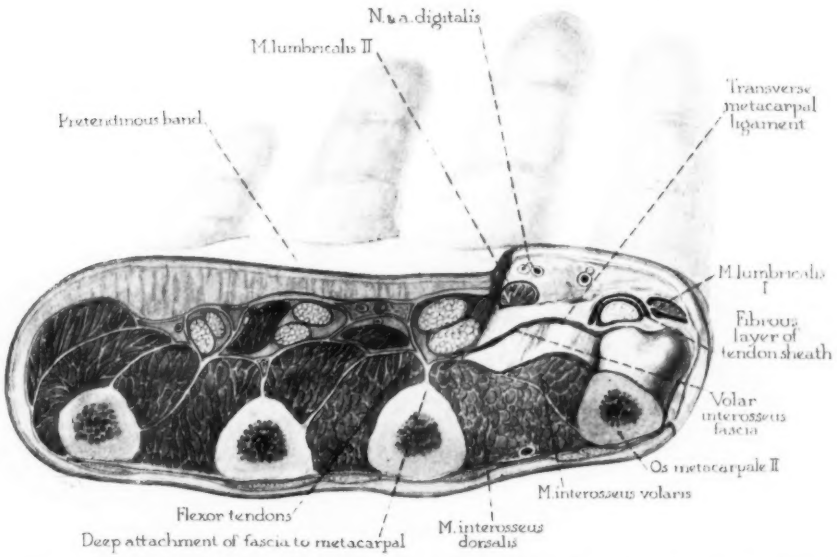


Fig. 9. Section to show the relation of the volar interosseous fascia to the transverse metacarpal ligament and the fibrous layer of the flexor tendon sheath (semidiagrammatic).

(Fig. 28), closely simulating the fascial thickening of the palm found in typical cases of Dupuytren's contraction before flexion contraction has occurred.

ETIOLOGY

Dupuytren's contraction is probably much more common in the later years of life than it is ordinarily considered to be. Among 300 men in the London Workhouses, Noble Smith found 55 cases or 18.3 per cent; among 400 women, 15 or 3.75 per cent. Of 270 men in the Nottingham Workhouse, Black found 57 cases or 21 per cent; and among 168 women, 3 cases, 1.8 per cent. Among 2,600 individuals of the poorer classes of London, of whom about five-sixths were past middle age Anderson found 33 cases, 1.27 per cent. Among 800 children in the Central District Schools of Hanwell there was not a single case. He states on the authority of Surgeon-Captain A. H. De Lom that in five years (1885–1889) from a force averaging 203,000 men between the ages of 17 and 35, only 3 cases of contraction of the fingers came under treatment. Among 1,000 men at the Cook County Poor Farm, Byford found 34 cases, 3.4 per cent. Among 106 women there were 3 cases, 2.83 per cent. Among 1,329 twist hands[1] in the Nottingham district, Black found 23 cases, 1.7 per cent. He states that from 1903 to 1909 among 50,224 patients admitted to St. Thomas' Hospital there were 21 cases of Dupuytren's contracture. Of 83,899 patients admitted to Wesley Memorial Hospital from January 1, 1916, to October 10, 1928, 30 suffered from Dupuytren's contracture. Of these, 28 were admitted on our service for operation and with a case from Ward 23 of the Cook County Hospital, form the basis of this report.[2] At least as many more in whom the disease did not cause any marked disability or in whom it accompanied some graver condition were seen by us in consultation during this period.

[1] Because it was stated that a large number of the lace "twisthands" or "minders" of lace machines in the Nottingham district were affected with Dupuytren's contraction, and that this prevalence was due to the continued trauma incurred in manipulating the levers and wheels of the lace machines, Black made a careful examination of 1,329 such individuals working in 68 different factories. He found among them only 23 cases of Dupuytren's contraction, or 1.7 per cent. Although he found a rather high percentage of the inmates of the Nottingham Workhouse affected with Dupuytren's contraction (57 of 270 males, or 21 per cent), only 20 of the 270 had worked as lace twisthands, and of the 20 only 3 had developed the disease.

[2] Our first patient was operated upon at the Post-Graduate Hospital in 1915. Unfortunately, his case history has been lost and we have been unable to trace him. This case, therefore, is not included in the series.

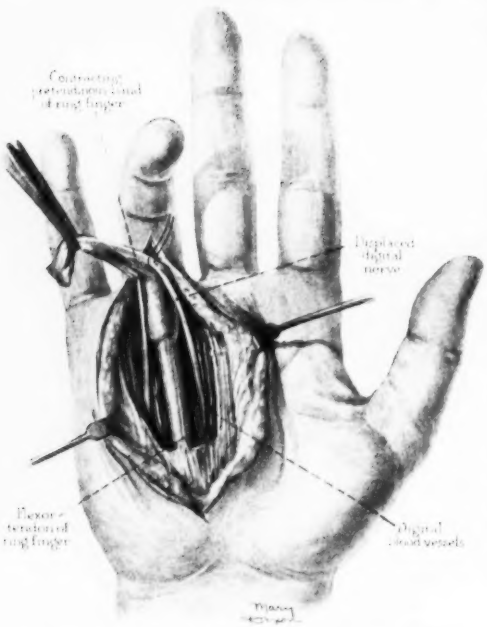


Fig. 10. Ulnar displacement of a digital nerve due to the progressive contraction of the digital fascia.
(Drawing made at operation upon Case 29.)

The condition may begin early in life[1] but is most frequently a disease of middle life and old age. In 90 cases collected by Keen the onset in 25 occurred before the age of 30 years, in 18 between 30 and 40 years, and in 47 after 40 years. In Anderson's series of 39 cases only one was under 40 years of age when the disease first appeared and 18 were past 60. In 38 cases reported by Byford the age at which the disease appeared varied from 25 to 68 years; the average was 47.7. In the 29 cases reported by us, the disease appeared at the age of 11 years in one patient 36 years old, at the age of 19 in our youngest patient, a man of 27, and at the age of 60 in our oldest patient, a man of 70. In 2 cases it appeared during the second decade, in 6 during the third, in 11 during the fourth, in 5 during the fifth, and in 5 during the sixth. The average age at which the disease was first noted was 36.9 years. The average age of 57 men with Dupuytren's contraction seen by Black at the Nottingham Workhouse was 63 years. The average age of Byford's cases was 70.8 years. The average age of our patients on admission to the hospital was 48.3 years; the average duration of the disease 11.4 years.

In spite of the marked tendency to superficial fibrous tissue formation seen in the colored races we have not seen a case of Dupuytren's contraction except in members of the white race.

The relative frequency of its occurrence in the two sexes, and of its occurrence in individuals who constantly use their hands as contrasted with those doing little manual labor, such as clergymen, physicians, bankers, clerks, etc., are indicated in Tables I and II.

TABLE I.—SEX

Author	Cases	Male	Female
Keen	227*	187	40
Anderson	39	25	14†
Black	240‡	221	19
Byford	38	35	3
Kanavel, Koch, Mason	29	27	2
	573	495	78

* Keen was able in 1886 to collect 253 cases including the 70 cases reported by Noble Smith. In his first article (1881) he states that he had personally seen 26 cases. He does not state in his second article, published five years later, how many additional cases of his own are included in the 253 collected up to that time.

† Anderson believes that Dupuytren's contraction occurs more commonly in females than is ordinarily considered, but that the disease is overlooked because it is less severe. Of the 14 cases seen by him, in 6 the disease was limited to the palm.

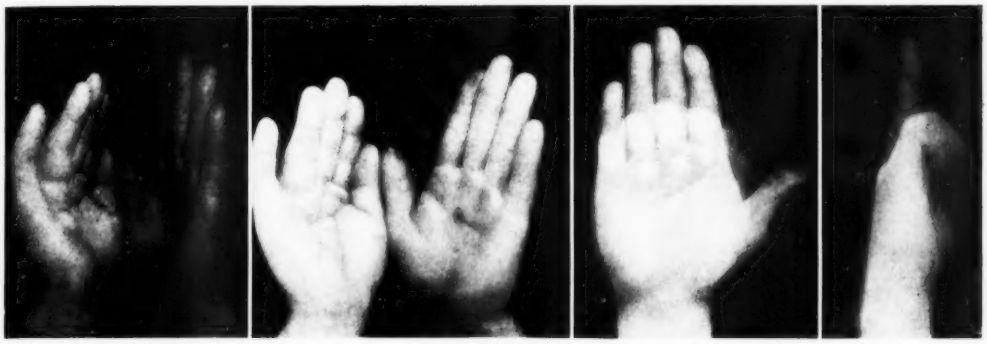
‡ Black was able to collect 240 cases including 60 from the Nottingham Workhouse, 23 from the factories of the Nottingham district, 131 from the practitioners of the Nottingham district, and 21 from the records of St. Thomas' Hospital, London.

TABLE II.—OCCUPATION

Author	Cases	Workers	Non-Workers
Keen	123	49	74
Black	131	63	68
Byford	38	24	14
Kanavel, Koch, Mason	29	10	19
	321	146	175

The frequency of the hand affected is shown in Table III.

[1] In the father, son, and grandson of a family said to have been affected with Dupuytren's contraction for the past 300 years, Bunch reported that the first symptoms—a slight curvature at the ulnar side of the little finger—appeared during the first few years of life. At the age of 25 the little finger became flexed and the contraction involved the ring finger as well. At the age of 35 the little finger was sharply flexed toward the palm so that the two distal phalanges were held almost parallel with the palm, and the distal phalanx of the ring finger was held at a right angle with the palm. In the 50-year-old father of this family the condition had remained stationary for 10 years. In the 25-year-old son there was beginning flexion of the little finger. The 3-year-old grandson showed the characteristic ulnar curvature of the little finger.



a. b. c. d.

Fig. 11. Bilateral involvement of the palmar fascia, with beginning contraction of the right ring finger, and a rather marked palmar nodule in the line of the left middle finger (Case 11). a, b, Before operation. c, d, Six months after operation.

TABLE III.—HAND AFFECTED

Author	Cases	R	L	Bilateral
Keen	184	58	23	103
Anderson	39	10	5	24
Hume	118	57	21	40
Black	240	89	47	104
Byford	38	9	4	25
Kanavel, Koch, Mason	29	4	8	17
	648	227	108	313

It is interesting to note that of the 29 cases reported by us in only 12 was the involvement unilateral, and of these in only 4 was the right hand involved. In our 2 female patients the left hand only was involved, and one of these was the only left handed patient in our series. Of 17 patients with bilateral involvement, in 3 both hands were equally involved; in 8 the right hand was involved the more, and in 6 the left.

With reference to the sequence of involvement of the two hands, data are difficult to secure. Keen states that in 26 cases of bilateral involvement, the involvement of the left hand appeared first in 15 cases. Of Byford's 25 cases with bilateral involvement, the involvement of the right hand preceded that of the left by 5.9 years in 10 cases; that of the left preceded that of the right by 4.2 years in 8 cases; in 5 the involvement was practically simultaneous; in 2 the relative time of appearance was unknown. In 4 of our 17 cases with bilateral involvement, the involvement was simultaneous. In 4 the right hand was involved first, in one case 2 years, in another 2 or 3 years, in another 10 years before the left was involved. In the fourth case in which involvement of the right hand had been present 3 years, the patient did not realize that the left palm was involved until the nodules were called to his attention. In 9 cases the left hand was involved first. In 2 cases the interval was 1 year; in 1 case 3 years, in 2 cases 6 years, in one case 7 years. In 2 cases the patient was uncertain as to the interval. In one case the involvement of the left hand, in this case affecting chiefly the palm, had been present for 20 years when involvement of the right ring finger appeared and in 9 months developed to the extent shown in Figure 14.

The part affected in 38 cases was recorded by Byford as the palm alone in 10 cases, the fingers alone in 2 cases. In 26 cases both palm and fingers were affected. In all of our cases the fingers of one hand at least were involved in the contraction, though among the 17 patients with bilateral involvement there were 9 in whom on one side the palm only was involved. In only one case were the fingers alone involved.

In 19 of our patients the contraction was first noticed in the palm. In 4 cases, 3 of them with involvement of the little finger, the trouble started in the proximal phalanx; in 1 case it began in the middle phalanx of the ring finger. In 1 case, with bilateral involvement,

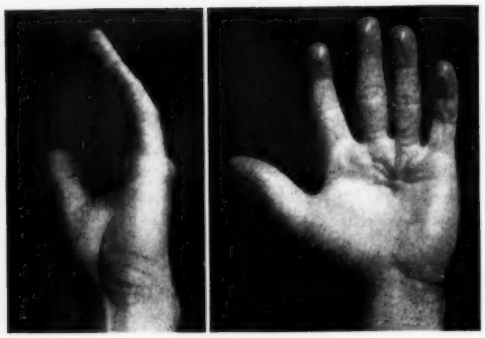


Fig. 12. A case of Dupuytren's contraction with marked palmar involvement and beginning contraction (Case 9).

the disease started in the left palm, and remained confined to the palm of this hand; 19 years later contraction began in the proximal phalanx of the right ring finger. In another case with bilateral involvement the process began at the proximal interphalangeal joint of the left ring finger, and 7 years later in the palm of the right hand. In another case the trouble appeared simultaneously in the left palm and the proximal phalanx of the right fifth finger. In 2 cases there is no record as to the primary localization.

The interval between the recognition of the disease and the beginning of the contraction was noted as "later," "several months later," "gradually contraction took place," etc. It was stated specifically as several months, 2 or 3 months, 3 months, 6 months, 1 year, 1 year, from 2 to 3 years, 5 years, 9 years, 9 years, 15 years, 16 years, 17 years and 21 years in as many different cases. In one case beginning flexion at the metacarpophalangeal joint of the fifth finger first called attention to the disease.

The frequency with which the different fingers are involved is indicated in Table IV.

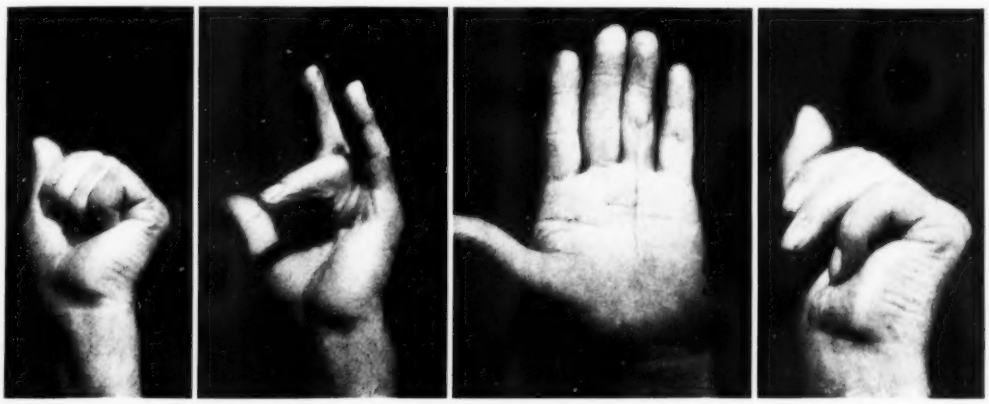
TABLE IV.—FINGER AFFECTED

Author	Cases	Thumb	Index	Middle	Ring	Little
Keen	214	11	24	73	199	165
Anderson	39	4	3	22	39	28
Byford	38	4	1	10	35	18
Kanavel, Koch, Mason	29	4	3	9	31	27
	320	23	31	114	304	238

In a statistical study of 105 cases Keen found the thumb was involved 9 times, never alone; the index finger 8 times alone, 7 times with other fingers; the middle finger 4 times alone; the ring finger 13 times alone; and the little finger 9 times alone. The middle and ring fingers were involved 7 times, the middle and little fingers once, the middle, ring and little fingers 17 times, and the ring and little fingers 36 times.

Among our patients there was one case with bilateral involvement of all the digits. In 8 others there were subcutaneous nodules in the web between the thumb and index finger. In one patient who came under our observation (not included in this series of cases), there was a characteristic involvement of the thin fascial band which extends from the thumb to the index finger just above and parallel to the web (Fig. 29). In no other case have we seen this entire fascial band involved. The index finger was involved 3 times, never alone; the middle finger 9 times, never alone. The ring finger was involved 31 times, 9 times alone; and the little finger 27 times, 6 times alone. The thumb, middle, ring, and little fingers were involved once; the thumb, ring and little fingers once; the index, ring and little fingers once; the middle and ring fingers twice; the middle, ring and little fingers 4 times; and the ring and little fingers 11 times. In 5 cases there was involvement of the right palm, and in 4 of the left palm associated with involvement of both palm and fingers of the other hand.

When several fingers of the same hand were involved, the involvement of the different fingers as a rule did not occur simultaneously nor to the same extent. In one patient with involvement of both ring and little fingers contraction began in the ring finger, and involvement of the little finger appeared "soon after"; in another case contraction of the ring finger followed that of the little finger after an interval of 6 years; in another similar case after an interval of 8½ years. In one patient with a marked contraction of the ring finger, contraction of the index and little fingers followed within two years after operation on the ring finger, although there had been no evidence of their involvement at the time of operation.



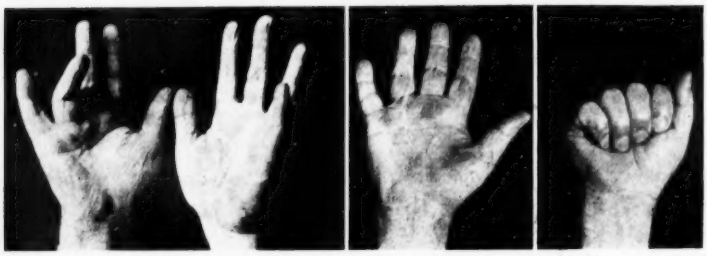
a. b. c. d.

Fig. 13. Dupuytren's contraction of left hand (Case 12). a, b, Before operation. c, d, Six months after operation.

With reference to the phalanges affected in cases of finger involvement, Keen states that in 57 cases the proximal phalanx alone was involved 15 times, the middle alone 7 times. The distal phalanx was involved 6 times. In 45 of 57 cases the proximal and middle phalanges were flexed. In 15 of these, flexion of the proximal phalanx preceded that of the middle; in 5 flexion of the middle phalanx preceded. In 25 cases the order of occurrence was not stated. Of our 29 cases with 64 fingers involved, there was flexion contraction at the metacarpophalangeal joint 50 times, at the proximal interphalangeal joint 40 times, and at the distal interphalangeal joint 9 times. Most commonly, therefore, there was flexion at the upper two joints and extension at the distal joint.

The cause of Dupuytren's contraction is still unknown. Many theories have been suggested for its origin, have been vigorously upheld by their protagonists and as vigorously opposed by others. Trauma, either a single, severe injury or the repeated traumatisms associated with certain occupations or sports (Dupuytren, Astley Cooper, Adams, Madelung, Vogt, Collis and Eatock, Russ, Ledderhose, Gill, Girdwood); a low-grade local inflammatory process (Langenbeck, Tubby, Ebstein, Jones, Whitman); systemic poisoning from lead (Michaud, Lamache and Picard), from the toxins associated with various constitutional diseases such as gout, "rheumatism," diabetes, arteriosclerosis, etc. (Guérin, Fergusson, Little, Keen, Adams, W. Anderson, Eulenberg, Pocci, Vogt, Richer, Teschemacher,[1] Nichols), or from chronic dental infection (Byford); the loss of the protective layer of subcutaneous fat which is associated with advancing age (Madelung, Ebstein); neurogenic influences (Abbe, Neutra, Teschemacher, Coenen); embryologic malformations (Krogius); heredity (Adams, Koenig, Bunch, Ebstein, Keen, Loewy); thyroid deficiency (Leopold-Levi) or a combination of these factors have all been suggested at different times as the cause of Dupuytren's contraction. The relatively large number of fibers passing from the palmar fascia to the skin on the ulnar side of the palm, and the slight decrease in the thickness of the skin on the ulnar side have been suggested by Russ as predisposing factors. The fact that the little and ring fingers are used more than the others in the act of grasping and flexed more tightly as the hand is closed has been suggested by Vogt as a predisposing factor.

[1] Among 213 diabetics Teschemacher found 33 cases of Dupuytren's contraction. He concluded from his observations that there is present in diabetics a peripheral nerve involvement with trophic disturbances, which may lead in some cases to Dupuytren's contraction, in others to pruritus, to dryness of the skin, or on the other hand, oversecretion of sweat, to splitting and loss of the hair and nails, to atrophy of the gums and to vulnerability to infection. He cites rather satirically the case of Dupuytren's coachman who because of Dupuytren's enormous practice had constantly to use the whip handle and so developed a contraction of the palmar fascia. Unfortunately for Dupuytren's theory of trauma, Teschemacher remarks, the coachman subsequently developed the same condition in the other hand.



a. b. c.

Fig. 14. Bilateral Dupuytren's contraction (Case 18). a, Before operation. b, c, Right hand 3½ months after operation. (The left has not been operated upon.)

Three of these theories deserve a brief consideration. The possibility of trauma as the essential etiological factor has suggested itself to many observers beginning with Dupuytren. Patients themselves invariably ascribe the onset of the trouble to a single or to repeated traumatisms, though it is frequently difficult to recognize a logical relation between the two. Sixteen of our 29 cases gave a definite history of trauma which in their minds at least was the essential factor in the development of the contraction. One patient stated that 4 years before injury a block of wood weighing 25 or 30 pounds fell on his hand. It cut "just through the skin." No attention was paid to the injury at the time. A month later he noticed the formation of a callus at the site of injury which gradually increased in size. Three years after the injury contraction of the ring finger began and in a year's time reached the condition shown in Figure 13. A second patient stated that he was struck with a wrench on the palmar surface of the proximal phalanx of the right ring finger. After some time, possibly 3 months, contraction of the finger began and in 9 months reached the degree of contraction shown in Figure 14. The same patient stated that the involvement of the left palm followed within a year after the left palm was crushed between 2 casks. (Like Dupuytren's famous case he was *un marchand du vin en gros*.) A third patient stated that in January, 1925, he caught his hand in the door of the garage as it was being closed. "Some months later" he noticed a lump on the left palm over the head of the fourth metacarpal bone. In May or June, 1925, he first noticed a beginning flexion contraction. A fourth patient stated that he received a puncture wound from a piece of copper wire over the metacarpophalangeal joint of the right ring finger. Slight discharge of pus persisted for a week afterward. Shortly after he noticed callus formation, and still later beginning contraction of the ring and middle fingers. A fifth patient, 44 years of age, had worked as a miner with pick and shovel since the age of 9. At the age of 38 or 39 involvement of the right hand appeared, and 2 years later involvement of the left. A sixth patient, whose hands were soft as a result of his work as a barber, started to work at 19 years of age in the harvest fields of North Dakota. His hands became so stiff and sore that he could scarcely bend his fingers. Three or four years later he noticed the appearance of small nodules in both palms. A seventh patient, a plasterer by trade, ascribed his trouble to the constant use of the left hand in holding the hod; an eighth

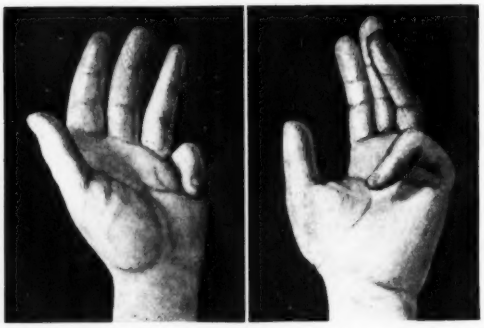
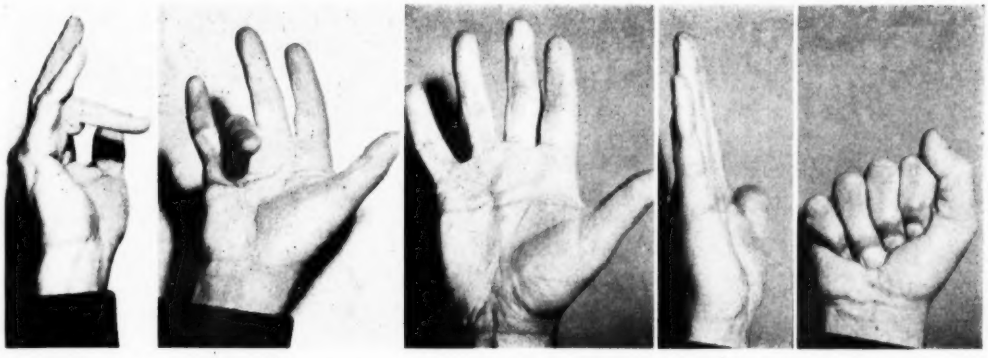


Fig. 16. Marked contraction of little finger developing during a period of nine years (Case 16).



a. b. c. d. e.

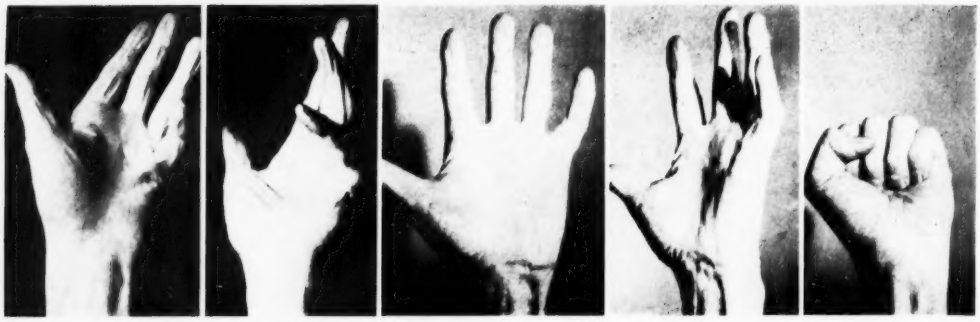
Fig. 15. Dupuytren's contraction of right hand (Case 25). a, b, Before operation. c, d, e, Nine months after operation. f, Bilateral thickening of plantar fascia in line of the great toes of the same patient.

f.

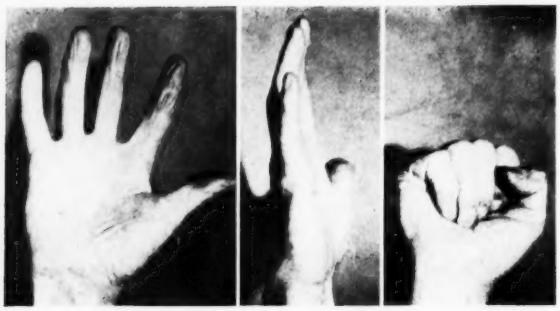
patient to having carried heavy sample cases; a ninth to a lacerated wound at the base of the right little finger; a tenth to a cut from a finger ring; an eleventh to constant contact with the knob-like top of the emergency brake of his car; and a twelfth to holding tightly the bridle reins of his saddle horse. Two patients, both bankers, one of 70 years with a history of 10 years' duration and one of 64 with a history of 20 years' duration, attributed the condition to the use of golf clubs.

These cases are cited in some detail because they are not convincing in establishing a definite and direct relation between the injury and the contraction. In the majority of cases there was a considerable lapse of time between the occurrence of the injury and the first signs of palmar involvement. In 2 cases in which the contraction was attributed to a definite injury (the first and fourth cases cited above) there was involvement of the palm of the opposite hand of which the patient had not been aware. It may be of some significance that both of these were industrial cases, i.e., patients for whose disabilities their employers were financially responsible if it could be shown that the disability resulted from injury sustained in the line of duty. The eighth patient, a physician, who attributed the contraction of the right little finger to a lacerated wound, had a contraction of the left little finger, almost identical with that of the right, for which he had no explanation.

The frequency with which Dupuytren's contraction involves the left hand in unilateral cases, the frequent involvement of both hands (Table III), the frequency with which it occurs in individuals doing little manual labor (Table II), the relatively infrequent occurrence of Dupuytren's contraction as compared with the infinite number of traumatisms of the hand of the same general character as those cited above which are constantly sustained in the course of everyday life and work, while all of negative value, still make it difficult to believe that trauma is the essential factor in the causation of the condition.



a. b. c. d. e.



f. g. h.

Fig. 17. Bilateral Dupuytren's contraction (Case 17). a, b, Left hand before operation. c, d, e, Left hand 23 months after operation. f, g, h, Right hand 11 months after operation. (The palmar involvement of the right hand was greater than that of the left but contraction of the fingers had not taken place.)

A second possible cause of Dupuytren's contraction, "a constitutional vice like gout or rheumatism," was first suggested by Guérin in 1843 and this theory has found many adherents. Because of the frequency with which a history of gout or rheumatism can be obtained, because the disease usually appears late in life, because of its infrequent appearance in women "who are as a rule exempt both from labor and from gout," because of its frequent occurrence in non-workers, because of the frequent involvement of the relatively little used ring and little fingers, because of the frequent involvement of the left hand as well as the right, and because of the absence of any signs of local inflammation, Keen felt convinced that the "cause lies deeper than any local influence, and that a constitutional vice like gout or rheumatism, if sought for, will nearly always be found."[1] Among 95 cases he found a distinct personal or family history of gout or rheumatism in 64. He quotes Chevrot as reporting a case in which the condition developed during an acute attack of rheumatism, and reports a case of his own in which the disease followed within a few weeks after an attack of acute rheumatism.

In spite of these facts, a careful inquiry into the past history of our patients failed to furnish a convincing argument in favor of the theory suggested. Seven of 29 patients gave a history of what might be called "rheumatism" but only one had had an acute rheumatic fever; in the others the condition was described as "slight," "slight aches and pains in legs and neck," "rheumatism of left shoulder for ten days," "rheumatism of both shoulder joints without fever," "periodical attacks of myositis of the back and chest," etc. Seven patients gave a history of recurring attacks of tonsillitis, 7 of gonorrhœal infection and 2 of both. One patient had had a chronic infection of the ethmoid cells for 10 years, another an osteomyelitis of the arm at the age of 8, another nasal catarrh since boyhood. In other words, the patients under observation had a record of past illnesses such as might be obtained from the average individual of the same age. In no case was a

[1] Philadelphia M. Times, 1881–2, xii, 370.

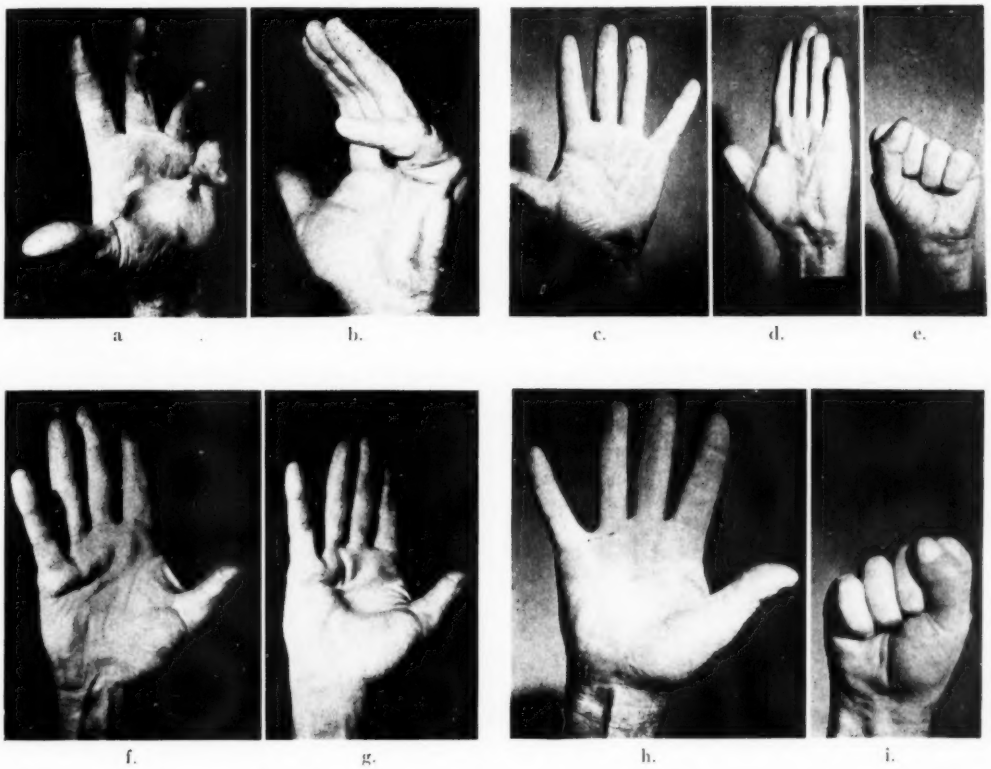


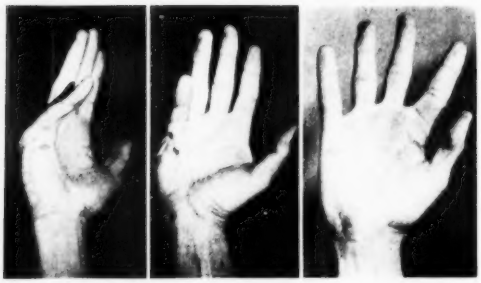
Fig. 18. Bilateral Dupuytren's contraction with marked deformity of left hand and palmar nodule at the base of the thumb (Case 27). a, b, Left hand before operation. c, d, e, Left hand 7 months after operation. f, g, Right hand before operation. h, i, Right hand 7 months after operation.

history of lead poisoning or of working in lead obtained.[1] Although several patients had had considerable dental work done only one had teeth which were described as being "worn down and in poor condition," and only two gave a history of dental abscess.[2]

[1] This is mentioned particularly because Michaud, Lamache, and Picard recently stated their belief that Dupuytren's contraction is as definite a sign of lead poisoning as the symptoms we are accustomed to associate with this condition; that among 33 patients with Dupuytren's contraction they found 24 with a history of having worked in lead, and of these 13 had well-developed signs of lead poisoning.

[2] Because he found evidence of dental infection in practically all his cases Byford concluded that focal infection, particularly infection about the teeth, is probably the cause of Dupuytren's contraction. As the result of our observations made over a considerable period of time at the Cook County Hospital, it would seem reasonable to assume that of individuals of 70 years, the average age of Byford's cases, at an institution like the Cook County Poor Farm the great majority would have lost their teeth or would show evidence of severe dental infection. That among 1,106 such individuals Byford found only 3.3 per cent affected with Dupuytren's contraction might equally well be construed as an argument against dental infection as the important etiological factor.

The third possible etiological factor, heredity, although only occasionally noted in the cases reported in the literature of Dupuytren's contraction does not admit of controversy. Concerning the influence of an injury no greater than the traumatisms which are constantly endured by manual laborers and individuals in every walk of life without permanent ill effects; or concerning the causative effect of "rheumatism," a symptom complex as common as Dupuytren's contraction is uncommon, one might argue at length. The occurrence of Dupuytren's contraction in successive generations, however, remains as a definite fact; and it seems to us of some significance that the cases in which a familial tendency is recorded are often among medical men,



a. b. c.

Fig. 19. Dupuytren's contraction of right hand with bow-string contraction of little finger (Case 23). a, b, Before operation. c, Nine months after operation.

in other words in individuals who would be interested in learning the facts and who would take the trouble to establish them.[1]

Six of our 29 patients were physicians. One stated that his father and paternal grandfather both suffered from a bilateral contraction of the ring and little fingers; another that his paternal grandfather had a bilateral contraction of many years' duration with the ring and little fingers of both hands flexed into the palm; another that a male cousin suffered from Dupuytren's contraction.

Of our patients who were not physicians one stated that his mother had a similar contraction of the left hand with involvement of the ring and little fingers, his mother's sister had a similar contraction involving both hands, and their father, the patient's maternal grandfather had a similar contraction of the right hand. Another patient's father and brother suffered from the same condition; two fingers of the father's hands were flexed half way into the palm, and the middle and ring fingers of the brother's left hand were involved in the same fashion. Another patient stated that his mother suffered from a palmar contraction identical with his own; a fourth patient that a brother had the same trouble; and a fifth that his father had several small hard nodules over the flexor tendons of the middle and ring fingers of one hand, but that the fingers were not flexed. Altogether 8 of 29 patients gave a definite familial history of Dupuytren's contraction.

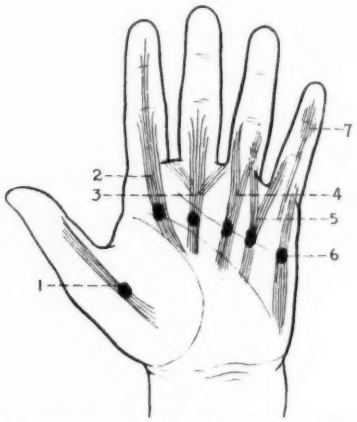


Fig. 20. Variations in the position of the contracting bands (after Wm. Anderson).

With reference to the cause of Dupuytren's contraction, therefore, we can only say that it is still unknown. None of our patients gave a convincing history of a traumatic origin of the disease. In none could the development of the disease be traced directly to an antecedent infection or illness, to a toxic condition, or to a lesion of the peripheral nervous system. Eight patients gave a history of a similar condition in other members of the family, and this hereditary tendency stands out as the most definite and tangible factor in the development of the disease. That there are other factors goes without saying, but what they are we are unwilling to conjecture.

SYMPTOMS

Subjective symptoms may occasionally be noted in the development of Dupuytren's contraction but they are uncommon. Five of our 29 patients complained of pain in the affected hand. One with a unilateral contrac-

[1] Jaerisch reported the case of a 42-year-old physician who stated: "As far as the etiology is concerned I can only mention a hereditary disposition. My hands were exposed to no special insults. On the other hand my father, who was a physician, had a similar contraction of the right ring finger; his brother, a farmer, about 75 years old and well, has a similar contraction of the left ring finger, and my brother, about 40 years old, has the same affection."

Keen was able to trace a history of familial involvement in 50 out of 198 cases. In 5 instances it occurred in 2 persons of the same generation, in 11 instances in persons of 2 generations, in 3 instances in persons of 3 generations and in one instance in one person of each of 4 generations.

Bunch's interesting paper recording the occurrence of Dupuytren's contraction in father, son, and grandson of a family of which the male members of the past three hundred years were said to be affected with Dupuytren's contraction has already been mentioned. The illustration of the father's hand is that of a typical case of Dupuytren's contraction. More recently Loewy has found individuals with Dupuytren's contraction in each of 4 generations of one family and Kartschikjan has traced the genealogy for 7 generations of a family of merchants in which a number of the male members suffered from Dupuytren's contraction.

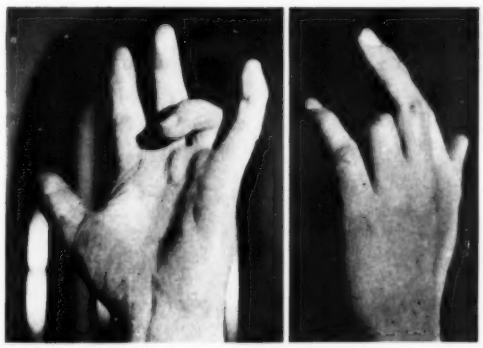
a. b. c. d. e. f.

Fig. 21. Bilateral Dupuytren's contraction with marked flexion of both ring fingers and nodules on the dorsum of the right middle and little fingers and left middle and ring fingers (Case 22). a, b, c, Right hand before operation. d, e, f, Right hand 11 months after operation. g, h, Left hand (not yet operated upon).

tion complained of an occasional cramping sensation in the affected finger and of occasional numbness. Another complained of a dull aching pain in the palm of the affected hand and at times of tenderness. A third and fourth said the palmar nodules were occasionally tender, and a fifth that at times he had a slight aching pain in the affected finger. The majority stated that the entire process had developed without subjective sensations of irritation or pain.[1]

The objective symptoms follow the pathologic changes so closely that they scarcely require enumeration. The appearance of the primary nodule in the palm of the hand, less frequently on the palmar surface of the ring or little finger, the development of other nodules, the gradual development after weeks, months, sometimes years, of a progressively increasing contraction, affecting most commonly the ring finger, and next in order of frequency the little finger, the gradual secondary involvement of other fingers and of the skin overlying the contracted fascia, the complete retention of the power of flexion and of joint movements, except as they are limited by the contracting band, and the secondary contraction of the joint capsule—are all a part of the classical textbook picture of the disease.

[1] Specklin and Stoeber reported a case of ten years' duration with involvement of both palms and soles and with intense neuralgic pains in the arms and legs. There was no evidence of neuritis, but the peripheral nerve trunks were tender. In Silva's case there were intense painful spasms in the feet.

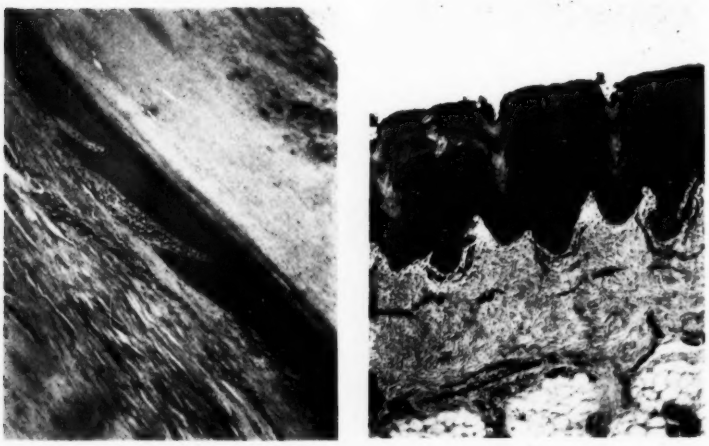


g. h.

DIAGNOSIS

In differentiating Dupuytren's contraction from other forms of contraction it is necessary to distinguish particularly contractions directly due to injury or infection,[2] congenital contractions and spastic contractions. Contractions following lacerated wounds associated with infection, particularly infections of the tendon sheaths, and contractions due to burns are readily distinguishable if a careful history is obtained. Several writers, particularly W. Anderson and Black, have stressed the importance of not confusing such acquired contractions with Dupuytren's contraction, particularly in attempting to secure statistical data from groups of elderly individuals whose memory for past events may be somewhat dimmed.

[2] Under the term camptodactyly, French writers—Horand, Milian and Crepin, Milian and others—have described a form of contraction of the hand which is characterized by sclerosis and thickening of the periarticular structures of the fingers, slight retraction of the flexor tendons, and sclerosis of the peritendinous tissues. The joint surfaces of the phalanges and the synovial membranes are unaffected and the metacarpophalangeal joints are not involved. The condition is usually considered a manifestation of a slowly developing and sclerosing tuberculous process.



a. b.

Fig. 22. a, Section of skin and subcutaneous tissue from palm of left hand shown in Figure 18. Note the thick corneal layer, the flattening of the stratum mucosum, the almost complete disappearance of the papillæ of the corium, and the manner in which they are drawn proximalward (to the left) by the fibrous tissue contraction (×68). b, Section of normal skin and subcutaneous tissue (×50).

Congenital contractions and spastic contractions are distinguished by their history, and by the fact that flexion at the wrist permits the affected fingers to be extended, since this movement produces relaxation of the tendons of the long flexors, the structures primarily involved in such contractions. Flexion at the wrist does not permit of extension of the affected fingers in Dupuytren's contraction, since this movement does not relax the contracted palmar fascia. In both congenital and spastic contractions there is characteristically complete extension or even hyperextension at the metacarpophalangeal joints, and flexion at the interphalangeal joints, in direct contrast to Dupuytren's contraction in which flexion usually occurs first at the metacarpophalangeal joints, and in which the distal interphalangeal joint is commonly unaffected. In both congenital and spastic contractions the dimpling and thickening of the palmar skin, the gradual development of palmar nodules and later of thick cords in the line of the pretendinous bands involving skin and fascia, which are so definitely characteristic of Dupuytren's contraction, are completely lacking.

Contractions of the fingers due to gout and arthritis deformans should not be difficult of recognition. Pain, tenderness, and swelling involving particularly the joints, exaggeration of the symptoms on movement, and the X-ray evidence of bone and joint changes leave no doubt concerning the diagnosis even if, as rarely happens, the process should be limited to one or two fingers on the ulnar side of the hand.

TREATMENT

Many methods of treatment have been suggested for Dupuytren's contraction and the literature of the subject contains numerous accounts both of successes and failures.

As early as 1822 Sir Astley Cooper observed: "The fingers are sometimes contracted . . . by a chronic inflammation of the thecæ and aponeuroses of the palm of the hand from excessive action of the hand in the use of the hammer, the oar, ploughing, etc. When the thecæ are contracted nothing should be attempted for the patient's relief, as no operation or other means will succeed; but when the aponeurosis is the cause of the contraction and the contracted band is narrow it may with advantage be divided with a pointed bistoury, introduced through a very small wound in the integument. The finger is

Fig. 23. Section of skin and subcutaneous tissue from palm of left hand shown in Figure 18 at the site of insertion of a fibrous band into the corium. Note the thickened corneum, the irregularity of the deeper layers of the epidermis and the obliquity of the papillæ and papillary vessels due to the upward retraction (to the left) of the contracting fibrous tissue (×74).

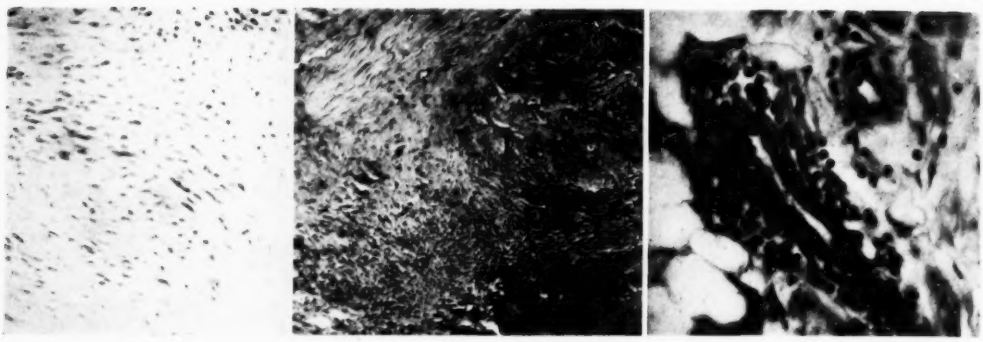
then extended, and a splint is applied to preserve it in the straight position."

In Dupuytren's *Leçons orales* one reads: "M. Dupuytren, in treating several cases of contraction of the ring-finger, employed one after the other vaporized fumigations, first of an emollient and then of a sedative character, plasters, . . . leeches, friction with resolvent ointments, particularly with mercurial ointments and calomel, alkaline, simple, sulphurous and saponaceous douches at various temperatures, and all without the slightest success. As a last resort, he prescribed permanent extension by means of an apparatus designed by Lacroix. No improvement resulted from the use of this instrument; on the contrary, it caused such intense pain in the palm of the hand, when the extension was maintained too long, that its use was abandoned.

"Some surgeons have proposed division of the flexor tendons. This operation has been performed twice. In the first case the tendon was cut in the center, the result was inflammation and mortification along the sheath, the patient's life was endangered, and the finger remained flexed. In the other case the division was made lower; no complications arose, but the part remained flexed as before.

Fig. 24. Section taken from a palmar depression near the metacarpophalangeal joint, resulting from the contraction of a longitudinal band terminating in the skin (Case 27). (The left edge of the pit is the proximal edge.) Note the pronounced corneal thickening, the disappearance of the papillæ along the bottom of the pit, the dense fibrotic corium with no trace of sweat glands or fat and with greatly decreased vascularity (×12.8).

Fig. 25. Section of skin from palm in close proximity to a palmar depression (Case 27). Note the thickened fibrous bands in the deeper layer of the corium (×11.8).



a. b. c.

Fig. 26. Sections of reticular layer of corium from palm of hand shown in Figure 40. a, Stained with Mallory's connective tissue stain (×192). b, Stained with hematoxylin-eosin (×100). c, Stained with hematoxylin-eosin (×325).

"Some time after these operations were performed, and by excellent surgeons, Dupuytren was consulted in a similar case by Dr. Mailly. . . . The operation was performed June 12, 1831, by M. Dupuytren, assisted by M. M. Mailly and Marc.

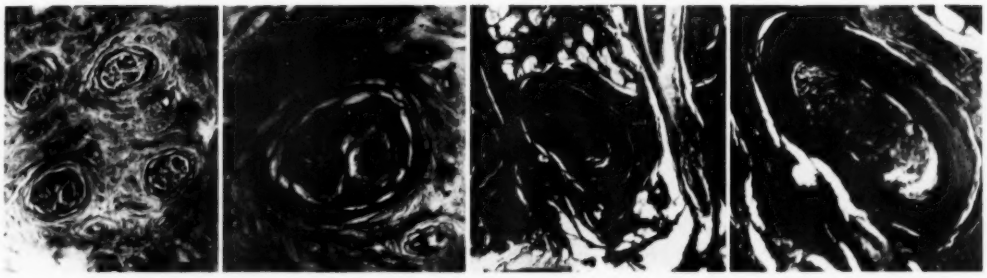
"The hand of the patient being firmly fixed, he (Dupuytren) commenced by making a transverse incision, ten lines in length, opposite the metacarpophalangeal articulation of the ring-finger. The bistoury divided first the skin and then the palmar aponeurosis, with a crackling noise audible to the ear. The incision completed, the ring-finger straightened, and could be extended almost as easily as in the natural state. Wishing to spare the patient the pain of a fresh incision, Dupuytren endeavoured to extend the section of the aponeurosis by gliding the knife transversely and deeply under the skin towards the cubital border of the hand so as to disengage the little finger, but in vain; he was only able partially to extend the incision of the aponeurosis. He therefore determined to make a fresh transverse incision opposite the articulation of the first and second phalanges of the little finger, and thus to detach its extremity from the palm of the hand, but the rest of the finger remained fixed to this part. He then divided the skin and aponeurosis by a fresh incision opposite the articulation of the metacarpophalangeal joint. This produced a slight relaxation, but its effects were incomplete. At length a third, and last incision was made transversely, opposite the middle of the first phalanx, and the little finger was soon extended with the greatest ease. This showed that the last incision had divided the point of insertion of the aponeurotic digitation."

The bleeding was stopped by "dry charpie" and the hand was immobilized in extension. Following the operation there was considerable swelling and pain, and on the fourth day "suppuration was completely established." The wounds healed in twenty days by cicatrization. When the extension was removed more than a month after the operation "the patient could easily flex the fingers, and was only inconvenienced by the stiffness resulting from the continued extension of the joints."

Goyrand in 1834 suggested making longitudinal incisions in the skin over the contracted bands, dissecting the skin from them and cutting across the isolated cords. After division of the fascia the skin edges were reunited and the fingers fixed in complete extension.

Busch also recommended the open operation. He dissected a triangular flap of skin from the contracted cord in the palm, divided all the bands of contracted fascia which could be reached and closed the lower part of the wound with sutures. After healing had begun cylinders of wood were laid in the hand to secure relaxation of the flexed fingers; later dorsal extension was applied but only when the wound was covered with granulation tissue. He emphasized the employment of active and passive movements, the use of the hand bath for cleansing the wound, and acceleration of the healing process by the use of skin grafts.

Fergusson emphasized the importance of open operation and *excision of the contracted fascia* so as to obviate the tendency to recurrence. He says of the tendency to recurrence: "So much is this the case, that if the offending part were very superficial, I should be inclined to dissect a portion of it out at once. . . . In many cases, I believe, this last named practice should be resorted to at first. An incision should be made lengthwise through the skin over the whole of the contraction and if the integument be tolerably soft and thick, it should be turned off on each side, so as to expose the fibrous tissue, which should then be carefully taken away. . . . In any, or all of these operations, the utmost care should be taken to avoid the nerves and blood vessels at each side of the finger, and if the stretching can be satisfactorily effected without opening a sheath or touching a tendon, so much the better, as then some movement might be expected afterwards; but if the ten-



a. b. c. d.

Fig. 27. Sections of reticular layer of corium from palm of hand shown in Figure 32 showing bundles of fibrous tissue surrounding bundles of nerve fibers. a, Stained with osmic acid (×225). b, Stained with osmic acid (×530). c. Stained with pyridine silver (modified Cajal method) (×100). d, Stained with pyridine silver (modified Cajal method) (×192).

dons require division, the finger must remain stiff, and, in anticipation of such an event, it will be well to consider what good can be expected from the proposed operation."

It would be difficult to express more concisely and clearly what we consider today the correct treatment of Dupuytren's contraction.

Although a number of successes were obtained by the operative procedures described, the number of failures, due to extensive suppuration of the operative wounds and the resulting extensive cicatrization, led to the employment of the so-called subcutaneous operation, first suggested by Astley Cooper. Guerin, Bouvier, Malgaigne, Velpeau, Fergusson, Little, Erichsen, Gant, Bryant, Druitt, Adams, and Keen particularly emphasized the simplicity and the favorable results of the subcutaneous operation[1] though Fergusson (as noted above), Erichsen and Bryant advocated the use of the open operation under certain conditions. The exclusion of air from the wound was particularly emphasized by the advocates of the subcutaneous operation (except Keen) as the essential factor in securing healing by first intention and in preventing the inflammatory reaction which was so likely to prevent a successful result.

In spite of many temporary and some permanent cures obtained by subcutaneous division of the contracted fascia this type of operation was gradually abandoned. As Keen says: "Subcutaneous divisions of the fascial bands, either single or multiple, as advocated by Adams, the open division of the skin and band together, the V-shaped incision of Busch, and similar methods which were necessary before the advent of aseptic surgery, are today not to be recommended, as with our present knowledge of the affection we must recognize their inadequacy. If used, they must be regarded as incomplete. The rational measure is, of course, the excision of the contracted band or bands."[2]

It is scarcely necessary to mention in addition to what has been said the many non-operative methods of treatment that have been and still are being used in the treatment of Dupuytren's contraction. The history of the treatment undergone by some patients is almost an exact repetition of the "atomised fumigations, plasters, leeches, frictions with absorbent ointments," etc., mentioned in Dupuytren's early experiences. Lacroix's instrument for producing permanent extension, and many modifications of it, have been used as well, and for a number of years after the discovery of electricity the static machine played an important part in the non-operative treatment. The injection of fibrolysin and paraffin, antileutic treatment,[3] the administration of thyroid preparations and the use of X-ray and radium are therapeutic measures of more recent origin. We have in no case seen lasting benefit resulting from their use.[4]

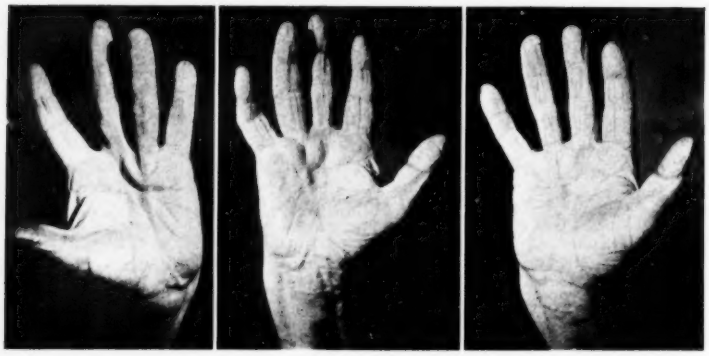
In the light of our experience, we believe that the essential factors in the treatment are as complete an excision of the palmar fascia as can be accomplished through the operative incision most suitable for the case in question, the excision of hopelessly affected skin and primary closure of the wound without undue tension. In some cases this may involve the

[1] Of the writers mentioned, only Erichsen, Druitt, Adams, and Keen recognized the fact that the palmar fascia alone was involved in the contraction, and some of them (Guerin, Little, Gant) even reported complete restoration of function with retention of flexion after subcutaneous division of both fascia and flexor tendons.

[2] In view of all that has been written concerning the pathology of Dupuytren's contraction, it is surprising that anyone should consider tendon lengthening in the treatment of this condition. Such a procedure, however, was recommended in 1927 by Rey.

[3] Silva reported a case with involvement of both hands and feet and painful spasms of the feet which was greatly improved under antiluetic treatment.

[4] Some years ago Spitzy suggested the injection of various foreign fats with low melting points about tendons involved in contractions resulting from infection or injury. More recently Stahnke has recommended for Dupuytren's contraction the subcutaneous injection of sterilized oil (humanol) obtained from lipomata and other human fat containing tissues. He has used this method in "about a dozen cases." He states that the nodules do not disappear from the palm but that extensibility of the fingers becomes practically complete and remains so.



a. b. c.

d. e.

Fig. 28. a, b, c, Bilateral Dupuytren's contraction with beginning contraction of the fingers. d, e, Bilateral contraction of the plantar fascia in the same patient.

use of a free full thickness graft of skin to replace the excised covering tissue.

Practically all of our cases have been operated on under local anæsthesia. This may be accomplished by infiltration with ½ per cent novocain without adrenalin or by a combination of median and ulnar nerve block at the wrist and local infiltration.

After infiltration is complete the arm is raised for a few moments and vascular constriction is secured by inflating the blood pressure band applied before beginning the operation.

The incision used depends upon the extent and location of the fascial involvement. In cases with three or four nodules lying in a transverse line across the palm, a transverse incision is made which extends well beyond the nodules of either side. The incision is usually made in the line of the distal flexion crease of the palm. The skin is carefully raised above and below the incision so as to expose the fascia over as wide an area as possible. Because the pretendinous bands are inserted into the corium, it is very easy to button hole the skin as it is freed from the underlying fascia, or to cut so close to it as to deprive it of its blood supply, with the result that a portion of it may undergo anæmic necrosis after operation. As the skin is elevated it is held out of the way with small flat retractors or a Kocher dissector. Every effort is made to avoid pinching it with tissue forceps or tearing it with sharp hooked retractors.

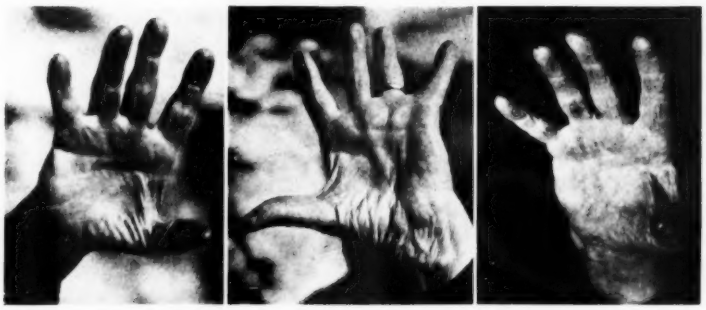


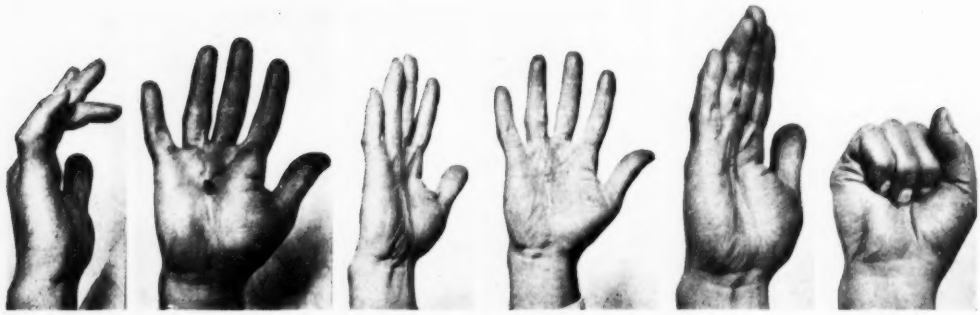
Fig. 29. Bilateral Dupuytren's contraction with marked involvement of the fascial band in the web between the thumb and index finger.

With the palmar skin elevated as far upward as the incision permits, the tense palmar fascia is divided transversely at the highest possible level, approximately on a line with the outstretched thumb. The moment the fascia is divided some relaxation can be noted and the proximal end of the distal portion can be raised slightly from the underlying structures.

Beginning proximally the fascia is separated by sharp dissection from its deep attachments—the intertendinous septa which bind it to the volar interosseous fascia, and from its lateral attachments. The farther distalward the dissection is carried the more careful must one be to avoid injury to the digital nerves. These appear between the interdigitations of the fascia as the pretendinous bands separate from one another to pass to their respective fingers. They lie in pairs, one for each side of the two fingers between which they lie. They are readily recognized when one is working in a bloodless field. As the dissection approaches the web of the fingers, one must be particularly careful to remove the fibers which pass deeply and merge with the transverse metacarpal ligament.

If instead of being confined to nodules lying across the palm the disease has gone on to the formation of a firm contracted cord which cannot be completely removed through a transverse incision, a longitudinal incision is made of sufficient length to expose the contracted fascia in its entirety, the skin is reflected to either side, and the fascia, including all of the contracted band with its deep and its lateral attachments, is removed as completely as possible. It is in this type of case that particular care must be exercised to avoid injury of the digital nerves, since not infrequently they are displaced from their normal position by the contraction that has taken place (Fig. 10).

It is in cases with firm, contracted cords, also, that one must occasionally resort to skin grafting to supply the defect left by the excision of the hopelessly involved skin. In cases where the viability of the skin is in doubt it is better to excise the questionable tissue and fill the defect with a graft than to risk necrosis of skin along the line of suture with the possibility of infection and delay in healing. To suture skin whose vitality is in question, and to suture it, as one is usually compelled to do under such circumstances, under slight tension, is to invite necrosis, separation of wound edges, and a long drawn out convalescence. In filling the defect left by excision of devitalized skin we have found the free full thickness graft, as described by Blair, Davis, and by ourselves in an earlier paper, the most satisfactory method. In one of our early cases we used a pedunculated graft from the lumbar region to cover the defect left by excision of scar tissue, but the result was not as satisfactory as the results of the application of a free full thickness graft have been; and the disadvantages as far as the duration of treatment and the discomfort of the patient were concerned were considerably greater. We have not had occasion to use the tubed flap method in the treatment of such cases, but



a. b. c. d. e. f.

Fig. 30. Dupuytren's contraction with flexion of right ring finger (Case 1). a, Right hand before operation. b, One month after operation. c, d, Three years after operation. e, f, Seven years after operation.

believe that in selected cases it might prove valuable if the tube were prepared and ready for transference at the time the palmar dissection was carried out.

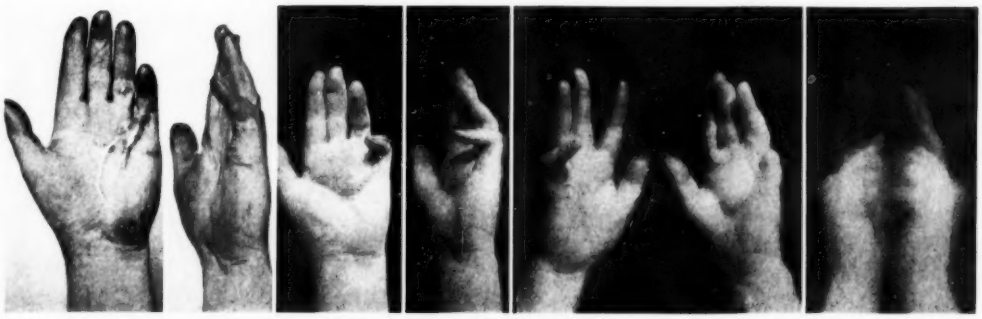
In two of our earlier cases (1 and 2), an incision in the form of a Greek gamma (γ) was used and after excision of the involved tissue a free flap of fat from the abdominal wall was placed beneath the skin. In one case there was primary healing; in the other a low grade infection developed and there was a slight discharge of serum and liquefied fat for weeks after the operation. In both cases the final result was good (Figs. 30, 32) but no better than in subsequent cases in which no transplants of fat have been used.[1]

In closing the operative wound, fine suture material and fine cutting needles are used, with Michel clips between every pair of sutures so as to evert the skin edges in an ectropion. Primary healing of the operative wound is of such great importance that it is worth while expending a little extra care to secure perfect apposition of skin edges—a more difficult task in the palm than in most parts of the body. Heavy needles and coarse silkworm gut cause holes in the skin that permit the entrance of bacteria into the subcutaneous tissues and predispose to wound infection even eight or ten days after operation.

[1] Kanavel, Peiser, and Gill independently conceived the idea of interposing a free transplant of fat between the skin and the underlying tendons after the excision of the palmar fascia. Kanavel's first case (Case 1) was operated upon June 16, 1916, and the method described before the St. Louis Medical Society, February 24, 1917. It was reported in the *Journal of the Missouri State Medical Association*, August, 1917. Peiser suggested the same method in 1917; and Gill in 1919.

POSTOPERATIVE TREATMENT

With our earlier cases we felt it was imperative after operation to splint the fingers in extension so as to stretch the flexor tendons of the affected fingers which had been permitted to remain for months or years in a relaxed position. After the fingers had been kept extended for two or three weeks, physical therapy was given to bring about as rapid restoration of function as possible. Because of the marked stiffness which resulted from immobilization in extension, the period of splinting and immobilization was gradually shortened, and in recent months we have used extension splints only in those cases in which there was marked shortening of the flexor tendons because of the long duration of the disease. Even in these cases splinting has been discontinued at the end of a week or ten days, and as a result the restoration of function has been more rapid. Though we feared that contraction of the fingers might tend to recur unless the flexor tendons were maintained in an extended position for a considerable period of time this has not occurred, and we have come to believe that the shortening of the ligaments about the small joints and the fibrous changes in these ligaments resulting from prolonged fixation in a flexed position are more important factors in preventing complete extension than the shortening of the flexor tendons; and that immobilization only for the period of wound healing, physical therapy and active movements of the fingers as soon as the danger of



a. b. c. d. e. f.

Fig. 31. Bilateral Dupuytren's contraction which had been operated upon several times before (Case 2). a, b, Left hand at time of admission. c, d, Left hand 3 years after first operation. e, f, Hands 3 years after second operation (amputation of distal phalanges of left little finger and excision of excess fat from palmar graft).

splitting the wound open by flexion of the fingers is past, are the most important factors in overcoming this disability.[1]

A word of caution may be added concerning the removal of the sutures. The thick skin of the palm of the hand does not heal as rapidly as the soft thin skin of the abdominal wall, and sutures must be left in place until healing of all of the layers of the skin is complete.[2] Clips should be removed in 6 or 7 days so as to avoid pressure necrosis from the metal points, but sutures should be left in place for two or two and one-half weeks. If small needles and fine suture material are used, there will be no irritation or reaction as a result of the prolonged retention of the sutures.

Occasionally after operation we have noted a considerable degree of cellular infiltration, evidenced by swelling, slight redness, and partial obliteration of the normal creases of the hand, coming on as late as the fifteenth or eighteenth day, and requiring a considerable period of time to disappear. It has occurred most frequently in cases in which a narrow area of anæmic necrosis developed in the skin along the line of incision, and in which complete healing was delayed until the necrotic skin could be replaced by the ingrowth of epithelium from the adjacent healthy tissues. The slow disappearance of the exudate from the tissues has occasionally been very trying to patients, and the process of absorption has not been appreciably accelerated by physical therapy, in fact, in such cases, manipulation has seemed to increase the amount of cellular infiltration and delay the restoration of function.

Another condition which occasionally has been an annoying postoperative complication is that of numbness along the side of a finger, or, in several cases in which a transverse incision has been used, in the area of the palm distal to the incision. This condition has at times developed in spite of every precaution to avoid trauma to the digital nerves, and in cases in which the continuity and integrity of all the digital nerves in the area exposed has been satisfactorily demonstrated. In no case has the anæsthesia been permanent, but it has occasionally been so prolonged as to form a source of anxiety to the patient, a fact that has impressed on us the necessity of handling the digital nerves as little and as gently as possible, particularly when dissecting them free from enveloping masses of fibrous tissue.

[1] Hutchinson, in 1917, emphasized the fact that in cases of long standing the ligaments on the palmar surface (glenoid ligament) and on the lateral surfaces (collateral ligaments), particularly of the proximal interphalangeal joints, are shortened because of continued immobilization in the flexed position, and that the shortening of these ligaments is the cause of contraction which persists after careful excision of the palmar fascia. He advocates, therefore, in such cases in addition to excision of the palmar fascia, division of the extensor tendon through a semilunar incision over the dorsum of the proximal interphalangeal joint and removal of the head of the proximal phalanx. After suture of the extensor tendon the "finger should become perfectly straight (or nearly so) without any tension whatever."

We have not used this method in any case, but believe that it might have helped to give a successful result in the one case (No. 16) in our series which was a failure.

[2] If necrosis of the skin takes place along the wound edges because the devitalized skin has not been entirely excised or because widely separated wound edges have been sutured under tension, healing is definitely delayed. The ingrowth of epithelium from the adjacent healthy tissues serves to take place more slowly in the palm and sole of the foot than elsewhere in the body. The process can be accelerated, however, by maintaining an even pressure over the surface with the aid of sea sponges, as suggested by Blair, until healing is complete.

a. b. c. d. e. f.

Fig. 32. Bilateral Dupuytren's contraction with marked contraction of right ring finger (Case 3). a, b, Right hand before operation. c, Right hand 7 months after operation. d, e, Right hand 5 years after operation. f, Left hand (not operated upon) 22 years after first appearance of palmar nodules.

RESULTS

Each of the cases operated upon has been carefully followed after operation, the first 3 cases now for a period of 12 years, and the results appraised with critical judgment.

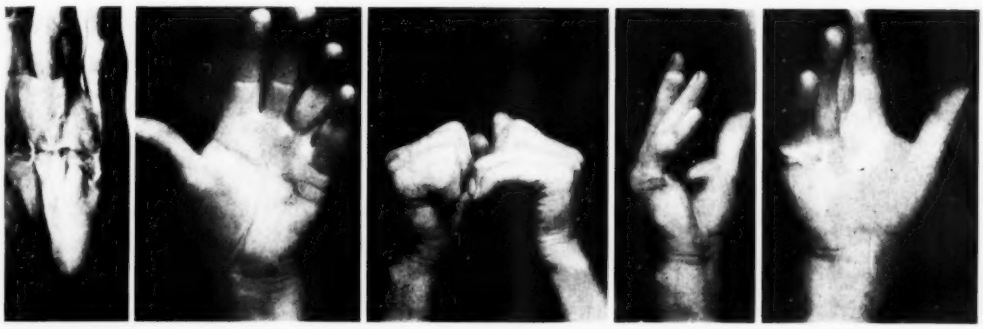
In 20 of the 29 cases the results have been good from a surgical standpoint, and completely satisfactory in the judgment of the patient. This group includes 2 cases in which palmar nodules at some distance from the operative incision appeared within a year after the primary operation. In both cases the nodules were removed at a second operation and no subsequent trouble has developed since —a period of more than 3 years in both cases. In the two last cases of the series (28 and 29) the period that has elapsed since operation has not been sufficient to render certain judgment, but their progress up until the present time leads us to believe that the result will be good.

In 5 cases (2, 3, 14, 16, and 24) the results were fair. The first of these (Case 2) had been operated upon elsewhere twice before and as a result presented a particularly difficult problem. The second (Case 3) developed a bilateral recurrence following our first operation: in the left hand because of incomplete removal of the palmar fascia at the primary operation; in the right because we attempted to swing a flap of skin from the ulnar side of the hand instead of filling the defect left by excision of devitalized skin with a free graft. The left hand was considerably improved by the second operation; the right hand was not operated upon a second time. The third and fifth cases (Cases 9 and 24) made an unusually slow recovery, chiefly because of inadequate care in the later postoperative period. In these cases we believe the final result will be good. The fourth case (Case 14) cannot completely extend or flex the affected little finger, but uses his hand in a normal fashion.

In 2 (Cases 8 and 16) the results were definitely unsatisfactory. The first had been operated upon six times previously, and finally had undergone amputation of several fingers. Needless to say complete restoration of function was scarcely to be hoped for. In the second case the prolonged fixation in acute flexion had caused a severe contraction of the periarticular structures of the metacarpophalangeal joint. Had this been compensated for by resection of the head of the proximal phalanx, as suggested by Hutchinson, the operation in our judgment would have been successful. Unfortunately the patient was unwilling to return for a second operation, so that the result in this case must be considered a failure.

SUMMARY

Twenty-nine cases of Dupuytren's contraction are reported which have served as an incentive for a careful study of the normal fascia of the hand, and an opportunity for observing the unusual changes which it undergoes in Dupuytren's contraction. Seven of these cases had been operated upon previously, some of them more than once and in each case



a. b. c. d. e.

Fig. 33. Bilateral Dupuytren's contraction with recurrence following operation (Case 4). a, Left hand 18 days after second operation, showing free full thickness graft. b, c, d, e, Right and left hands 2 years after second operation.

the condition had recurred. The results observed in such cases, and the results obtained in the cases operated upon by us have impressed upon us the importance of:

1. Wide excision, not only of the contracted fascia, but of all its attachments to the skin, the interfascial septa, the volar interosseous fascia, the metacarpal bones, and the phalanges. Although in such an operation apparently normal fascia may be removed we do not consider this a disadvantage but rather an added guarantee against recurrence.

2. Careful dissection and elevation of the skin to avoid trauma and subsequent necrosis.

3. Painstaking effort to avoid injury or division of the digital nerves and blood vessels which are frequently imbedded in the bands of fibrous tissue which draw the fingers into flexion.

4. Excision of skin that is hopelessly involved, and replacement of the excised skin by a free full thickness graft rather than attempting to bring together wound edges under tension.

5. In long standing cases with marked contraction of the fingers, excision of the head of the proximal phalanx and shortening of the extensor tendon of the affected fingers through a dorsal incision (Hutchinson's operation).

6. Active movement of the fingers and hand as soon as the operative wound is soundly healed.

If treated in such a manner complete restoration of function may reasonably be hoped for, although cellular infiltration of the hand and partial anæsthesia and stiffness of the fingers may persist for a considerable period of time after the operation.

CASE HISTORIES[1]

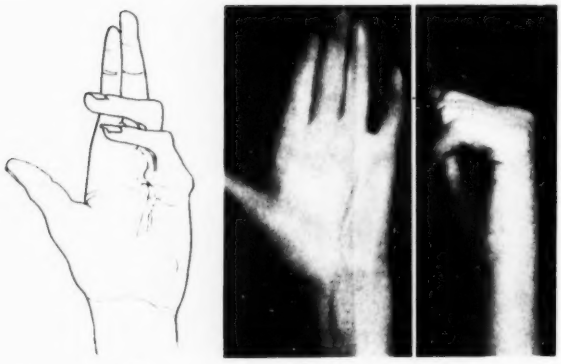
CASE 1. (W. M. H., 59872.) Male, 41 years, telephone operator. Ten years before admission the patient "bruised" his right hand. The contraction present (Fig. 30, a) gradually developed during the ensuing years. His only past illness was a gonorrhœal infection "years before" admission. Two years before admission the hand had been operated upon elsewhere but the condition recurred.

On June 16, 1916, under gas and ether anæsthesia, through a Y-shaped incision, with the right limb of the Y extended distally along the radial side of the ring finger, the affected fascia was excised, and a free flap of fat interposed between the skin and deeper tissues. Slight separation of the wound edges took place at the angle of the Y when the sutures were removed, and liquefied fat and serum were discharged from the wound for some days thereafter. Fig. 30, b, shows the result 1 month after operation; c, d, 3 years after operation; and e, f, 7 years after operation.

CASE 2. (W. M. H., 79317.) Male, 36 years, barber. Twelve years before admission the patient first noticed the development of nodules in both palms which he described as "feeling like peas in the soft tissues." He ascribed the trouble to the fact that at the age of 19, 5 years before the appearance

[1] Some of the following case histories are much more complete than others. Every attempt, however, has been made to supplement them by questioning patients after operation and by correspondence.

It is a pleasure to acknowledge our indebtedness to the internes on our service at Wesley Memorial Hospital during the years in question for their interested and painstaking assistance, particularly to Dr. M. T. Phy, Hot Point, Oregon; Dr. J. C. Carver, Hammond, Indiana; Dr. H. M. Barker, Peter Bent Brigham Hospital, Boston; Dr. F. M. Thurmon, Massachusetts General Hospital, Boston; Dr. C. H. Warfield, Dr. W. W. Brandes and Dr. H. A. Haven, Chicago.



a. b. c.

Fig. 34. Dupuytren's contraction of left hand (Case 5). a, Before operation. b, c, Five months after operation. (The vertical line in *b* is due to a defect in the photographic plate.)

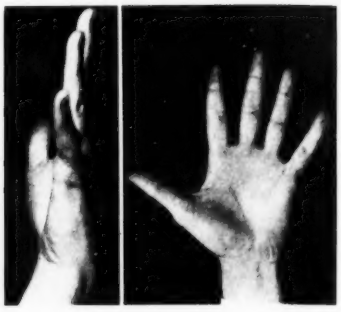


Fig. 35. Dupuytren's contraction of left little finger (Case 6). Result 2 years after operation.

of symptoms, he worked for some weeks in the harvest fields of North Dakota. His soft hands became so stiff and sore that he could hardly open and close them. This disability gradually disappeared. Four or 5 years later the first nodules appeared.

He sought medical relief and for 6 months was treated by the application of a dressing saturated with a solvent solution. Since this was without effect, electrical treatment was given for some months with the aid of a static machine, but also without any helpful result. In 1915 both hands were operated upon elsewhere through a Y-shaped incision. The hands healed very slowly. At the end of 6 months, there was still an unhealed area as large as a 25-cent piece in the center of the left palm. When the hands were finally healed there was a firm scar at the base of the little finger of the right hand, and marked scarring of the left palm. About a year later these scars were divided subcutaneously and the hands splinted in extension, but with little improvement.

He had had typhoid at the age of 21, and a gonorrhœal infection at the age of 23, which cleared up rather rapidly but recurred a year later. His mother, aged 70 in 1925, had involvement of both palms, "exactly similar to the condition of the patient's hands," which began at the age of 64 years.

The condition of the left hand on admission in 1919 is shown in Figure 31, a, b. Because of the firm scars present, it was felt that a covering of normal skin was essential for a successful result. This was secured with considerable difficulty by the use of a single pedunculated flap from the abdominal wall. Because it had but one pedicle the flap was made thicker than ordinarily to ensure an adequate blood supply (Fig. 31, c, d). Because of infection which developed at the ulnar side of the flap some sloughing took place and the subsequent scar tissue formation produced a cicatricial contraction of the palmar skin over the little finger with a recurrence of the flexion deformity of this finger.

Three years later, in 1922, the left hand was again operated upon, and the contracted digital fascia of the ring and little fingers was excised. Because of the extensive loss of skin over the palmar surface of the little finger and the very extensive fibrosis of all the tissues a complete excision of scar tissues was impossible and the contraction of the little finger again recurred. Because of its interference with his work as a barber this finger was subsequently amputated and at the same time some of the excess fat removed from the palmar transplant. The final result is shown in Figure 31, e, f.

Case 3. (W. M. H., 79767.) Male, 46 years, minister. Twenty years before admission the patient first noticed "small indentations" of the palm of the right hand. Two or three years later a similar condition appeared in the left hand. Four years before admission flexion contraction of the right ring finger began and gradually reached the degree shown in Figure 32, a, b.

He had had "rheumatism" when 13 years of age.

June 27, 1919, under gas and ether anæsthesia, through a + shaped incision, with the transverse limb opposite the distal flexion crease and the distal portion of the vertical limb extending 3 centimeters along the midline of the ring finger, the affected palmar fascia was excised and a free flap of fat from the right thigh interposed between the skin of the right hand and flexor tendons. The wound healed by primary union.

Figure 32, c, shows the condition of the hand seven months after operation; d, e, the hand in September, 1924, five years after operation; and f, the left hand, which was not operated upon, in September, 1924.

Case 4. (W. M. H., 101583.) Male, 44 years, miner. Six years before admission he noticed a gradually developing flexion deformity of the right

Fig. 36. Dupuytren's contraction with bilateral involvement of little finger (Case 7).

Fig. 37. Bilateral Dupuytren's contraction of 35 years' duration (Case 8).

little finger and, later, involvement of the ring finger. Three years before admission the left little finger and ring finger became involved. Since the age of 9 he had worked as a coal miner with pick and shovel.

Twenty years before admission he had had a gonorrhœal infection with 2 exacerbations; 12 years before admission he had had 2 attacks of malaria.

Both hands were operated upon June 6, 1922. In both there was marked involvement of skin as well as deeper structures. On the right side an incision was made in the form of an inverted L(⌐) with the vertical limb extending upward on the ulnar side of the hand, and the transverse limb across the palm to the midline of the hand, approximately in the line of the distal flexion crease. Three firm cords of contracted fascia were found, two arising from a single band higher in the palm and involving adjacent sides of the little and ring fingers, and a third on the radial side of the ring finger. After wide excision of the involved skin and fascia, the skin flap was rotated radialward on its base so as to compensate for the excision of hopelessly fibrosed skin, and the wound sutured. On the left side vertical incisions were made in the median line of the ring and little fingers, and the contracted cords removed through these incisions.

The left hand healed well, but on the right some necrosis took place because of tension on the sutures and healing was not complete until 4½ weeks after operation.

Four months after operation the patient returned because of recurrence of the condition in the left hand. October 2, 1922, under local anæsthesia the palmar fascia on the ulnar side of the hand, which had not been excised as completely as it should have been at the first operation, was carefully removed. A small defect in the skin covering was filled with a free full thickness graft, the first to be used by us in such a case.

Figure 33, a, shows the result 18 days after the second operation on the left hand and Figure 33, b, c, d, e, the result in both hands 2 years after operation.

Case 5. (W. M. H., 112301.) Female, 59 years, housewife, left handed. Eight years before admission the patient noticed a small, painless nodule on the ulnar side of the left palm. Two or 3 years later flexion contraction began in the ring finger and soon after in the little finger. She occasionally noticed cramping sensations and numbness in the affected fingers.

Fifteen years before admission she had had arthritis of both shoulder joints unaccompanied by fever.

At operation under local anæsthesia, May 21, 1924, through a vertical incision in the line of the pretendinous band of the little finger, the involved fascia was excised and the hand splinted in extension.

Figure 34, a, shows the condition before operation; b, c, the result 5 months after operation.

Case 6. (W. M. H., 114870) male, 40 years, physician. Two years before admission the patient first noticed a small nodular growth on the palmar surface of the left little finger at the level of the proximal interphalangeal joint. This gradually increased until several months later, when he noticed that he was unable completely to extend the little finger. The contraction gradually increased, until at the time of admission the patient was unable to extend the little finger at the metacarpophalangeal joint beyond a right angle. There were no subjective symptoms of pain or tenderness. There was no history of local infection or injury.

a. b. c. d.

Fig. 38. Bilateral Dupuytren's contraction (Case 10). a, b, Right and left hands before operation. c, d, Result 9 months after operation on right hand.

He had had jaundice at the age of 25; frequent attacks of tonsillitis until the tonsils were removed at the age of 30; and pneumonia followed by bilateral empyema at the age of 33.

He stated that a cousin suffered from the same condition.

October 8, 1924, under local anæsthesia, the palmar fascia on the ulnar side of the hand and a thick cordlike mass of fibrous tissue, lying on the ulnar side of the left ring finger and attached distally to the fibrous tissue overlying the flexor tendons and to the fibrous tissue and periosteum on the ulnar side of the middle phalanx were excised through an elongated zig-zag incision. A left inguinal hernia was repaired at the same time.

There was some necrosis of the skin edges along the line of incision which delayed healing, but the patient left the hospital 3 weeks after operation with the wound healed. After discharge from the hospital physical therapy was begun and continued for a number of weeks. Figure 35 shows the condition of the hand in January, 1927, 2 years and 3 months after operation. Flexion of the fingers was not impaired at any time.

Case 7. (W. M. H., 117176) male, 42 years, physician. Sixteen years before admission he sustained a slight laceration of the palmar surface of the left hand at the base of the little finger. A slight flexion deformity gradually developed as a result. Six years later he first noticed puckering and hardening of the skin of the right palm at the base of the ring and little fingers, which gradually went on to a flexion deformity at the metacarpophalangeal joint of the little finger (Fig. 36). There were no subjective symptoms except slight aching pain at times and the inability to extend the fingers completely.

He gave a history of pyrexia and headaches of unknown etiology 12 years before admission, of typhoid and phlebitis of the left leg and right arm 5 years later.

At operation, February 18, 1925, under local anæsthesia a zig-zag incision was made along the ulnar side of the right little finger. Two cords of fibrous tissue extending from the distal flexion crease of the palm to the proximal interphalangeal joint were carefully dissected out. The larger and stronger radial cord was firmly adherent to the overlying skin, but superficial to the digital nerve. The digital nerve on the ulnar side was intimately united with the fascial cord.

The patient was discharged from the hospital 2 days after operation. Some dry necrosis of the edges of the skin along the line of incision occurred with subsequent superficial wound infection. Healing was complete with the finger in extension 3 weeks after operation, but numbness along the ulnar side of the finger persisted for a number of months after operation. The left hand was not operated upon.

Case 8. (W. M. H., 119058) male, 57 years, physician. Thirty-two years before admission, at the time of his graduation from medical school, the patient noticed nodules developing in both palms. He had always been in good health except for periodical attacks of myositis.

His father had a bilateral contraction of the fourth and fifth fingers, and his paternal grandfather had a similar condition.

He was operated upon by three different surgeons, by one of them on six different occasions. In his own words "the tendency was toward recurrence, and the recurrence plus scar tissue caused disability so extensive that several fingers were amputated." About 3 years before admission, June 1, 1925, a growth appeared in the scar tissue on the ulnar side of the right middle finger and this became so painful and distressing that he again sought surgical relief, not with the idea of having the contraction cured, but because of the painful nodular growth. It was possible to excise this, as well as some of the scar tissue holding the finger in flexion; and had he been willing to undertake physiotherapeutic treatment and wear a splint for some time the condition would probably have been

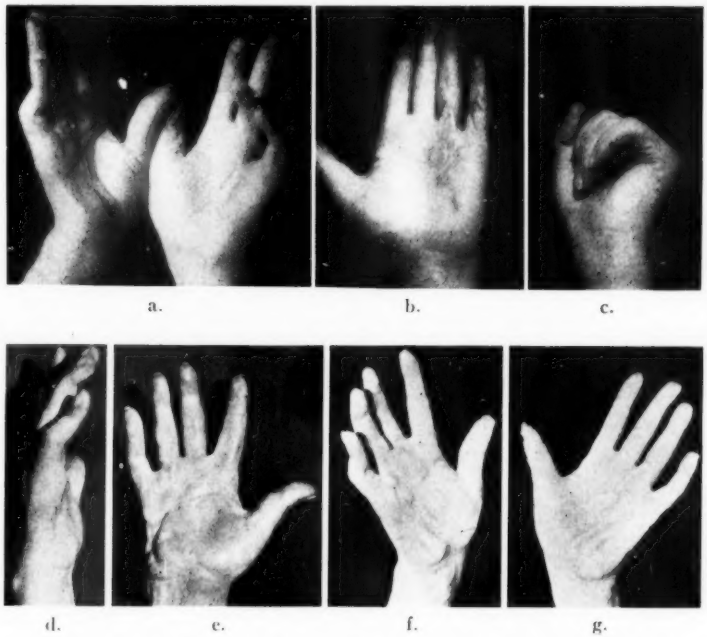


Fig. 39. Bilateral Dupuytren's contraction (Case 13). a, Before operation (both hands previously operated upon elsewhere). b, c, Left hand after operation. d, e, Right hand after operation. f and g, Hands 3 years after operation on left hand and 14 months after operation on right.

improved. As it is he writes that he has had very marked comfort and freedom from pain, but the right middle finger has again contracted to about a right angle. (Fig. 37.)

Case 9. (W. M. H., 119094) male, 41 years, Y. M. C. A. secretary. Four years before admission the patient first noticed callus formation in the left palm, which gradually became more marked and more nodular in character. Later contraction developed which involved the ring finger and middle finger, and which at first progressed very slowly but, during the year before admission, more rapidly. The patient ascribed the involvement to constant use and irritation of the hands in various sports, particularly baseball. He had noticed in the 6 months preceding admission that the hand became very sore and stiff when it was used, particularly in the sports to which he had been accustomed.

He had had a slight attack of rheumatism at 29 years.

The appearance of the hand before operation is shown in Figure 12. There was a definite subcutaneous nodule also in the web between the thumb and index finger.

June 3, 1925, under local anæsthesia, the involved fascia was excised through a longitudinal incision in line with the interspace between the ring and middle fingers. The nodule between the thumb and index finger was removed through a second incision on the dorsal surface just over the area involved. The fingers were splinted in extension. Following the operation there was a slight necrosis of the skin edges along the line of incision. The patient left the hospital with the wound healed 15 days after operation.

Six months later the patient wrote: "I can straighten my fingers but it is like pulling against stiff rubber bands. The joint of the middle finger is still sore and stiff." The latter condition probably resulted from the prolonged extension of the finger on a dorsal splint, a method of postoperative treatment which has since been abandoned.

Case 10. (W. M. H., 119193) male, 70 years, banker. Ten years before admission the patient noticed a lump at the base of the left little finger which he thought a callus caused by his golf clubs. Contraction gradually took place. Some time later, he could not say definitely when, a similar condition developed in the right hand. The patient ascribed the condition to the constant trauma of the hands associated with playing golf. He complained of some "tenderness of the nerves" of the left hand.

He had had "inflammatory rheumatism" as a young man.

a. b. c. d.

Fig. 40. Dupuytren's contraction with flexion of little finger (Case 14). a, Before operation. b, c, d, Two and one-half years after operation.

At operation under local anæsthesia on the left hand, June 8, 1925, a vertical incision was made in a line between the ring and little fingers. The palmar fascia was widely excised, and the hand splinted in extension. The right hand was not operated upon.

Figure 38, a, b, shows the condition before operation; c, d, the condition 9 months after operation.

CASE 11. (W. M. H., 121033) male, 35 years, electrician. Three years before admission the patient punctured the skin over the palmar surface of the right ring finger at the level of the metacarpophalangeal joint with a piece of copper wire. There was a slight infection of the wound which subsided within a week. Some time later a nodule appeared at the site of injury, and later contraction developed which at the time of admission had reached the degree shown in Figure 11, a, b.

The patient gave a history of frequent colds, but of no other illnesses. There were thick calluses over the bases of the proximal phalanges on both palms.

September 14, 1925, under local anæsthesia, a long ellipse of palmar skin, the underlying fascia and the fascia on either side as far as it could be reached were carefully excised. The hand was splinted in extension and the patient left the hospital 4 days after operation. The wound healed by primary union.

May 15, 1927, the patient returned to the hospital with four nodules in the subcutaneous tissue of the right palm, two at the level of the distal flexion crease of the palm in the line of the little and ring fingers, respectively, and one at either side of the middle flexion crease in the line of the index finger. These nodules were excised on the following day through a transverse incision in line with the flexion creases. The patient left the hospital 2 days later; the wound healed by primary union and there has been no further evidence of recurrence. Figure 11, c, d, shows the range of movement of the fingers 6 months after operation.

CASE 12. (W. M. H., 121163) male, 51 years, carpenter. Four years before admission a heavy block of wood, 25 or 30 pounds in weight, fell on the patient's left hand. It cut just through the skin of the ring finger. The hand was not bandaged and the patient paid little attention to the injury. A month later he noticed a callus forming at the site of injury. The callus gradually increased in size until 3 years after the injury when contraction of the ring finger first became apparent. At the beginning of the winter (1924–25) he had a little difficulty in putting on his glove because of the flexion contraction; at the end of the winter he was unable to put a glove on the affected hand (Fig. 13, a, b).

He had had measles and scarlet fever in childhood and appendicitis followed by a postoperative pneumonia 14 years before admission. He had had "rheumatism" of the left shoulder for 10 days 5 years before admission and "rheumatism" of the right shoulder 3 years later. He had many fillings in his teeth and some bridge work.

September 23, 1925, under local anæsthesia, the contracted palmar fascia was excised through a vertical incision in the midline of the ring finger. The hand was splinted by extension. The wound healed by primary union and the patient left the hospital on the sixth day. Physical therapy was begun 10 days after operation and continued every other day for a month.

A month after leaving the hospital the patient noticed a dimpling and retraction of the skin in the line of the left middle finger. This gradually increased until November 2, 1926, when the skin was elevated under local anæsthesia through an incision in the line of the middle finger, and the pretendinous band of the middle finger removed. The patient

a. b. c. d. e. f.

Fig. 41. Dupuytren's contraction of left hand (Case 15). a, b, Before operation. c, d, One year after operation. e, f, Two years after operation (note the complete restoration of the power of flexion).

left the hospital on the fourth day. The operative wound healed by primary union. At that time small nodules were noted for the first time at the base of the ring and little fingers of the right hand. Figure 13, c, d, shows the appearance of the hand and range of movement of the fingers 5 months after operation.

CASE 13. (W. M. H., 123230) male, 27 years, collector. Six years before admission, while serving in the United States Navy, the patient noticed callus-like formations in the palms of both hands. Gradually cord-like thickenings appeared in each hand which drew first the ring finger and later the little finger down toward the palm.

Eight years before admission he had an attack of influenza followed by meningitis.

In June, 1925, the left hand was operated upon elsewhere. Recurrence of the contraction occurred soon after.

In August, 1925, the right hand was operated upon elsewhere, and the fingers kept in extension for 6 weeks afterward. Following the operation the fingers remained stiff, the patient was unable to flex them, and the flexion deformity at the proximal interphalangeal joint of the little finger began to recur.

January 26, 1926, the left hand was operated upon under local anæsthesia. An elongated oval of dense superficial scar tissue was carefully dissected out, the skin elevated at either side, and the involved fascia removed. The oval defect in the skin was covered with a free full thickness graft. The appearance of the left hand before and after operation is shown in Figure 39, a, b, c.

February 4, 1927, the right hand was operated upon under local anæsthesia. The thickened palmar fascia on the ulnar side of the hand was carefully excised, and the flexor tendons of the middle, ring, and little fingers examined. They were firmly held within the flexor tunnels by fibrous tissue and the superficial flexor tendons, adherent to the deep flexor tendons. Extension of all the fingers was almost complete (Fig. 39, d, e) following the operation, and flexion greatly improved with the aid of a prolonged course of physical therapy.

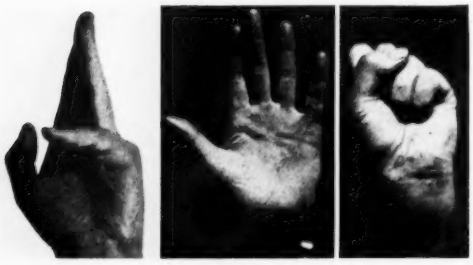
In May, 1928, the scars over the proximal portion of the right ring finger, and over the hypothenar eminence were excised and the resulting defects covered with free full thickness skin grafts.

CASE 14. (W. M. H., 123379) male, 64 years, banker. Twenty years before admission the patient noticed the formation of a nodule on the palmar surface of the proximal phalanx of the left little finger. Gradually other nodules appeared in the palm, in the line of the ring finger, and 5 years before admission he noticed a beginning flexion contraction at the proximal interphalangeal joint of the little finger, which gradually continued until the second phalanx was flexed to an angle of 45 degrees on the first phalanx. About 15 years before admission the patient noticed a subcutaneous nodule in the right palm with beginning retraction of the skin in the line of the ring finger at the level of the distal flexion crease. He thought that it developed after he had knocked to pieces some old boxes with a very heavy hand ax. He ascribed the disease in the left hand to irritation from the head of his putter while playing golf.

The patient gave no history of past illnesses or infections.

February 3, 1926, under local anæsthesia, through a vertical incision in the midline of the little finger the affected fascia was carefully excised. Many tiny millet seed sized white bodies were noted lying along the digital nerves, and attached to them by tiny fibrils as peas are attached to a pod. These tiny bodies proved on microscopic examination to be tactile corpuscles.

The fingers were splinted in extension. The operative wound healed by primary union, but the site of operation gradually became swollen, slightly inflamed and tender as though by a diffuse cellular infiltration of the tissues about the site of operation. This condition, in spite of baking, massage, and physical therapy, subsided very slowly and pre-



a. b. c.

Fig. 42. Dupuytren's contraction with cord-like contraction of pretendinous band of the left little finger (Case 19). a, Before operation. b, c, Eighteen months after operation.

vented free use of the hand, particularly flexion of the fingers for a period of 6 weeks after operation.

Two and one half years after operation he reported: "I have the use of all of the fingers of the right hand excepting the finger that was operated upon, but have difficulty in completely closing the other fingers; in fact if I attempt to get them down close to the palm of the hand I can feel a pain in the knuckles. I can grasp any object in doing any kind of work, such as shoveling coal in the furnace, without difficulty. The lump in the palm of the hand has entirely disappeared."

Figure 40 shows the condition of the hand before operation, and two and one-half years after operation.

CASE 15. (W. M. H., 123809) male, 55 years, claim adjuster for state railways. Fourteen months before admission the patient's left hand was bruised by a garage door. Some months later he noticed a lump in the palm at the head of the fourth metacarpal. Five or 6 months after the injury he noticed an increase in size of the lump, beginning contraction at the metacarpophalangeal joint and wrinkling of the palmar skin.

There was no history of past illnesses except that of frequent colds in the head and chest, nor of similar contraction in other members of the patient's family.

There were subcutaneous nodules, just above and below the distal flexion crease in the line of the ring finger, and a smaller nodule just below the crease in the line of the middle finger. There was marked puckering, dimpling, and induration of the palmar skin in the line of the ring finger, and slight beginning contraction of the ring finger (Fig. 41, a, b).

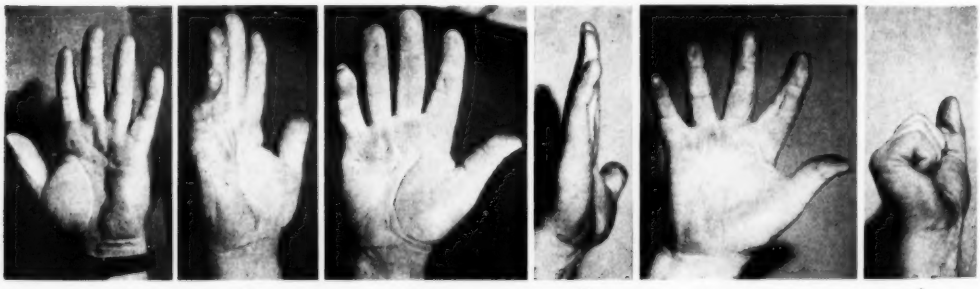
On March 2, 1926, under local anæsthesia, the contracted fascia was excised through a longitudinal, slightly curved incision with its convexity ulnarward. The hand was splinted with the fingers extended.

The patient left the hospital 9 days later with the wound completely healed. The result one year and two years later is shown in Figure 41, c, d, e, f.

CASE 16. (W. M. H., 128578) male, 36 years, salesman. Fourteen years before admission he noticed a dimpling of the left palm at the junction of the distal flexion crease and hypothenar eminence. Nine years later he noticed beginning flexion deformity of the little finger. One year before admission he was unable to put the finger in a glove, and noticed that the nail of the little finger was beginning to press into the palm. Five or 6 months before admission, flexion of the ring finger became apparent and thereafter progressed rather rapidly to the condition shown in Figure 16.

The patient attributed the onset of the trouble to having carried heavy sample cases once while on a selling trip. He never carried them a second time, and never did other hard manual labor. His father had two small hard nodules over the tendons of the middle and ring fingers of one hand, but the fingers were not flexed.

The patient gave a history of repeated infections of the eyelids, of recurring attacks of tonsillitis about once yearly, of removal of two teeth because of abscesses 4 years before admission and of acute appendicitis and appendectomy 3 years before.



a. b. c. d. e. f.

Fig. 43. Bilateral Dupuytren's contraction (Case 20). a, Left hand (not operated upon). b, c, Right hand before operation. d, e, f, Right hand 13 months after operation.

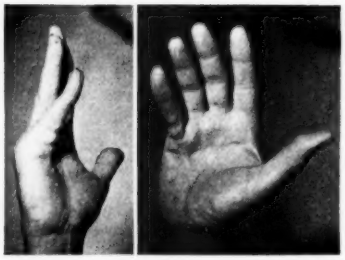


Fig. 44. Dupuytren's contraction with marked involvement of palmar skin and contraction of right little finger (Case 24).

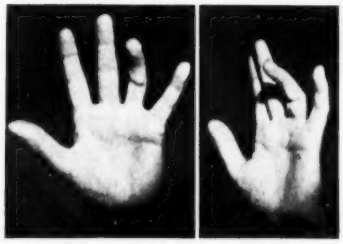


Fig. 45. Dupuytren's contraction with pathology confined to left ring finger (Case 26).

At operation under local anæsthesia, November 23, 1926, the contracted fascia was excised through a vertical incision over the little finger, parallel with the contracting band, and a second vertical incision over the proximal phalanx of the ring finger. A small, free full thickness graft was used to cover a defect over the distal portion of the palm between the affected fingers. The hand was splinted in extension.

After the operation the patient suffered considerable pain because of the tension required to maintain the fingers in the extended position, and the resultant pressure on the dorsum of the extended finger. It finally became necessary to relieve the tension with the result that the pressure over the skin graft was released and subsequently necrosis of the graft took place. Ten days later the raw surface was covered with a Thiersch graft and wound healing took place without further difficulty. In the meantime, however, because of the relaxation of tension, and continued immobilization the little finger again became partially flexed and the final result was unsatisfactory. In spite of repeated attempts we were unable to persuade the patient to return for a second operation.

In this case it might have been wiser to have resected the head of the proximal phalanx, as suggested by Hutchinson, so as to shorten the bony framework and thus compensate for the shortening of the articular ligaments.

Case 17. (W. M. H., 128884) male, 64 years, examiner for civil service commission. Seven years before admission the patient noticed a beginning callus formation on the palm at the base of the little finger. An ointment was applied at the advice of a dermatologist, but without effect. Gradually a contraction developed at the metacarpophalangeal joint which prevented complete extension of the finger. Three years before admission the hand was operated upon under local anæsthesia, "the tendon of the little finger pulled out and scraped." There was no improvement, but the contraction gradually increased. A year before admission involvement of the ring finger was first noticed. The condition of the left hand upon admission is shown in Figure 17, a, b. At that time there was also palmar involvement of the right hand but no contraction of the fingers.

The patient had had a gonorrhœal infection at the age of 20, and an operation for tuberculous glands of the left side of the neck at 42 years. He had had some dental decay within the 7 years preceding admission.

One brother suffered from a similar condition.

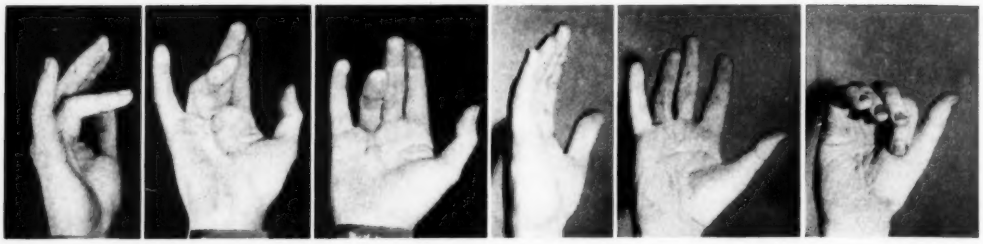
December 13, 1926, under local anæsthesia, the affected fascia of the left hand was excised through a curved incision beginning distally over the base of the little finger and curving radially toward the base of the thenar eminence. The hand was splinted with the fingers in extension. The patient left the hospital 5 days after operation. The wound healed by primary union.

December 31, 1927, the patient re-entered the hospital for operation upon the right hand, in which contraction of the ring and little fingers was then becoming apparent. The same day under local anæsthesia the affected fascia was excised through a transverse incision in the line of the middle flexion crease of the palm. Particular attention was directed toward excising the paratendinous septa connecting the palmar aponeurosis with the volar interosseous fascia. The patient left the hospital 3 days after operation. The wound healed by primary union.

Figure 17, c, d, e, shows the condition of the left hand November 17, 1928, almost two years after operation, and Figure 17, f, g, h, the right hand on the same date, 10½ months after operation. The patient himself feels that he has had a complete restoration of function.

Case 18. (W. M. H., 129451) male, 56 years, wine merchant. Twenty-one years before admission the patient's left hand was caught between two casks. Within a year a nodule appeared at the level of the distal flexion crease of the palm in line with the cleft between the ring and little fingers. A slight contraction developed and remained practically unchanged during the following 20 years (Fig. 14, a).

One year before admission the patient's right hand was struck with a wrench. Some time later a



a. b. c. d. e. f.

Fig. 46. Dupuytren's contraction with involvement of palmar skin and contraction of ring finger (Case 29). a, b, c, Before operation. d, e, f, Five weeks after operation.

nodule appeared at the middle of the palmar surface of the proximal phalanx, and either at the same time or a little later other nodules appeared in the palm. Contraction began soon after and within 8 or 9 months reached the degree shown in Figure 14, a.

The only medical history of interest was that of an operation for hæmorrhoids one year before. There was no history of a similar condition in other members of the family.

January 19, 1927, under local anæsthesia the contracted palmar fascia of the right hand was excised through an elongated S-shaped incision. The patient left the hospital 6 days later. The wound healed by primary union. The result 3½ months later is shown in Figure 14, b, c. The left hand was not operated upon.

Case 19. (W. M. H., 132267) male, 52 years, lawyer. Two years before admission the patient noticed a small lump on the palmar surface of the proximal phalanx of the left little finger. There were no subjective symptoms of pain or tenderness. One year later he noticed stiffness and difficulty in extending the finger at the metacarpophalangeal joint. This difficulty gradually increased until at the time of admission the finger was flexed to an angle of 90 degrees at the metacarpophalangeal joint (Fig. 42, a). Complete extension was possible at both interphalangeal joints.

He had had "gastric fever" for 2 weeks at the age of 27; erysipelas at 35, and a nasal operation at 35. He had had considerable peridental infection.

There was no history of a similar condition in other members of the family.

On June 18, 1927, under local anæsthesia, the contracted palmar fascia and its attachments were widely excised through a vertical incision along the contracted fascia in the line of the little finger. The patient left the hospital 5 days later.

The operative wound healed by primary union. The result 18 months after operation is shown in Figure 42, b, c. At that time the patient stated: "The operation was entirely successful though for a considerable time I did not have free use of the hand. The tissues in the palm were thickened and hard, and I could not entirely close the hand. I have had an osteopathic physician treat the hand for the past year, and it has reached the stage now where I can close it almost as well as the other hand upon which no operation was performed. It is not yet entirely as satisfactory as the other hand, but I have no doubt that in a few months more it will be perfect. The scar has largely disappeared and I have had no pain or any other symptom of discomfort for several months. For a considerable period of time, there was a feeling of numbness in the palm, and there is still a slight thickness in the tissues of the palm and a slight numbness. However, I can use the hand practically as well as I ever could."

Case 20. (W. M. H., 135081) male, 54 years, merchant. Twenty years before admission the patient first noticed a small nodule on the ulnar side of the palmar surface of the proximal phalanx of the right little finger. Shortly afterward flexion contraction began in the proximal interphalangeal joint. Ten years before admission a nodule appeared at the junction of the distal flexion crease and the pretendinous band of the ring finger, and during the following 6 years other nodules above it and at either side. Gradually flexion contraction of the ring and middle fingers developed, and that of the little finger increased.

Involvement of the left hand also began 20 years before admission, but was confined to two nodules at the junction of the distal crease of the palm and the pretendinous band of the little finger, and a third nodule near the base of the thumb.

The patient gave no history of trauma or local infection. He had had pneumonia at 9, typhoid fever at 20, tonsillitis once or twice a year until tonsillectomy was performed at the age of 39.

November 7, 1927, under local anæsthesia, a strip of skin ½ inch wide, and the palmar fascia of the right hand were carefully excised through a transverse incision in line with the distal flexion crease of the palm. Healing was delayed by slight necrosis of the skin edges along the line of incision, but was complete 24 days after operation. Restoration of function, however, was delayed by the development of a cellular infiltration of the palm which persisted for a number of weeks in spite of physical therapy.

The condition of the hand before operation and one year after is shown in Figure 43.

CASE 21. (C. C. H., 1038589) male, 52 years, plasterer. Three years before admission the patient first noticed a callus in the palm of the left hand at the junction of the distal crease and the pretendinous band of the ring finger. Gradually flexion contraction of the ring finger and little finger developed until at the time of admission the proximal phalanx of the ring finger was held at an angle of 140 degrees or 145 degrees with the corresponding metacarpal bone, the proximal phalanx of the little finger was held at an angle of 125 degrees or 130 degrees, and the middle phalanx of the little finger was flexed to an angle of 90 degrees on the proximal phalanx. The range of movement of the other joints was normal.

The patient ascribed his condition to constant irritation of the hand with a plasterer's tool. He gave no history of local or general infection or of a similar condition in other members of the family.

November 18, 1927, under local anæsthesia, the affected fascia was excised through a longitudinal incision from the proximal flexion crease to the proximal interphalangeal joint of the ring finger, and through a second shorter longitudinal incision in the line of the little finger. The hand was splinted with the fingers in extension. The wounds healed by primary union and the patient left the hospital 10 days after operation with the fingers completely extended without tension.

CASE 22. (W. M. H., 136397) male, 36 years, supervisor of a finance corporation. As long as he could remember the proximal interphalangeal joint of the left ring finger was slightly enlarged. About 25 years before admission he noticed a beginning flexion which gradually increased until extension was limited to 65 degrees (Fig. 21, g, h). Seven years later a similar condition developed in the right ring finger and progressed until extension at the proximal interphalangeal joint was limited to 60 degrees (Fig. 21, a, b, c.) In the 15 years previous to his admission nodules appeared on the dorsum of the fifth and middle fingers of the right hand (Fig. 21, a, b, c) and the ring and middle fingers of the left hand (Fig. 21, g, h). In each case they were over the proximal interphalangeal joint: the largest, 3/8 inch in width, on the right fifth finger was in a median position; the others, smaller in size, lay to the ulnar side of the finger affected.

This patient gave no history of injury which might have caused the condition. He had had occasional sore throats until 4 years before admission when his tonsils were removed. He had had 2 gonorrhœal infections, 16 and 12 years before admission. No other members of his family were similarly affected.

January 25, 1928, under local anæsthesia, the fascia of the right hand was widely excised through an elongated S-shaped incision at the ulnar side of the ring finger, extending from the middle of the middle phalanx upward to the middle of the palm. The digital nerve at the ulnar side of the ring finger was displaced radialward by the contracting band and the natatory ligament between the ring and little fingers pulled sharply upward. The dorsal nodule lying over the proximal interphalangeal joint of the right middle finger was also excised. It lay in the subcutaneous tissues, superficial to the extensor tendon.

The hand was splinted in extension and the patient left the hospital 4 days after operation. Healing was delayed by a superficial wound infection but was complete 24 days after operation. The result 11 months after operation on the right hand is shown in Figure 21, d, e, f. At that time the patient stated that his only disability was the inability to flex the ring finger completely. The left hand has not yet been operated upon.

CASE 23. (W. M. H. 136603) male, 47 years, superintendent for street railway company. Fifteen years before admission he noticed a nodule appearing just distal to the intersection of the distal flexion crease of the palm with the pretendinous band of the right fifth finger. Five years later a median cord appeared over the proximal phalanx, and flexion began at the metacarpophalangeal joint. In 10 years flexion increased until extension was limited to an angle of 95 degrees. In the 5 years preceding admission other nodules appeared on both sides and in the middle of the palmar surface of the proximal phalanx of the fifth finger, and in the pretendinous band of the ring finger (Fig. 19, a, b).

The patient gave no history of trauma. He had had a gonorrhœal infection some years before, and a tooth extracted because of infection 3 years before.

His mother had a similar contraction of both hands; in one hand it was severe, in the other less so. The fifth finger of one hand was flexed into the palm, and the ring finger to an angle of 120 degrees. The patient's maternal grandfather had a similar contraction of the right hand with the ring and little fingers flexed into the palm, and a maternal aunt had a bilateral contraction, more marked on the right side, with involvement of the ring and little fingers.

February 6, 1928, under local anæsthesia, through a longitudinal incision parallel with the contracting cord, the palmar fascia was widely excised.

The patient left the hospital 4 days after operation. The wound healed by primary union. The condition and function of the hand before operation and 9 months after operation are shown in Figure 19.

CASE 24. (W. M. H., 136599) male, 48 years, physician. Twelve years before admission he first noted a nodule on the palmar aspect of the proximal interphalangeal joint of the right fifth finger. Six years later a second nodule appeared a half inch proximal to the first. Three years later a nodule appeared in the palm at the intersection of the pretendinous band of the fifth finger with the distal flexion crease of the palm. At the same time he noticed beginning flexion at the metacarpophalangeal joint of the fifth finger.

Two years before admission he noticed the appearance of slender cords over the palmar surface of the left index and fifth fingers opposite the proximal interphalangeal joints (Fig. 44).

He ascribed the beginning of the trouble to striking his palm repeatedly against the emergency brake of his car, which was released by pressing downward on a knob about the size of the end of his thumb. Ten years after the onset of the trouble a bruise of the right hand, sustained in raising a boat, seemed to aggravate the condition. A month later the palmar nodule was removed. An infection developed after operation and persisted for about 2 weeks. After healing occurred, the contraction became progressively worse.

The patient gave a history of chronic tonsillar infection and of chronic ethmoidal sinusitis of 10 years' duration. Two years before the symptoms of Dupuytren's contraction appeared his tonsils were removed and all his teeth extracted.

His paternal grandfather had a contraction of both hands of many year's duration. The fourth and fifth fingers of each hand were completely flexed into the palms but the distal interphalangeal joints were not affected.

February 6, 1928, under local anæsthesia, the involved palmar skin in the line of the fifth finger and the contracted fascia of the finger and palm were widely excised, leaving a rather wide L-shaped defect when the finger was extended. A free, full thickness graft from the right thigh was sutured over the defect. Because of a blood clot under the proximal portion of the graft, a portion of it, about the size of a 25-cent piece, became necrotic, but healing of the raw surface took place rather rapidly by ingrowth of epithelium from the adjacent edges.

A few weeks after his discharge from the hospital, 11 days after operation, the patient developed an influenzal infection and shortly after returned to his home in California.

Eleven months after operation he wrote, "The hand has been very stiff until two weeks ago, but it is beginning to loosen up."

Had we been able to keep closely in touch with this patient during the later postoperative period, and had physical therapy been wisely applied we believe that much of the delay in the restoration of function might have been avoided.

CASE 25. (W. M. H. 136816) male, 53 years, civil engineer. Twenty-four years before admission he noticed a nodule between the distal and middle flexion creases of the left palm in the line of the pretendinous band of the middle finger. This gradually became more pronounced until a taut cord developed which did not, however, produce flexion of the finger.

Twenty-three years before admission a similar nodule developed in the right palm at the intersection of the distal flexion crease and the pretendinous band of the ring finger. Eighteen years later a taut cord developed in the line of the ring finger, which extended from an inch above the wrist to the proximal interphalangeal joint. Three years later flexion began and continued until some 6 months before admission when it seemed to become stationary.

The patient ascribed the development of the condition to holding the bridle reins with a tight grip while horseback riding, and "straining the cords" of his hands during frequent youthful demonstrations of his powerful grip. Two years before admission he bruised his hands while playing baseball, after which the flexion contraction seemed to be accelerated.

He stated that he had suffered from nasal catarrh since early youth.

His father and brother suffered from a similar contraction. Two fingers of one of his father's hands were flexed half way into the palm, and the middle and ring fingers of his brother's left hand were similarly involved.

The condition of the patient's right hand before operation is shown in Figure 15, a, b. The condition of the patient's feet, in both of which there was a firm, thick, subcutaneous cord with definite nodules along the medial border of the foot is shown in Figure 15, f.

February 20, 1928, under local anæsthesia through an elongated S-shaped incision along the line of the ring finger, from the level of the outstretched thumb to the middle of the middle phalanx, the palmar fascia was widely excised. The patient left the hospital 3 days after operation. On the radial side of the incision, at the base of the ring finger, a narrow elongated area of superficial necrosis developed with subsequent sloughing of the skin. This area was completely healed 2½ months after operation, but as a result of the scar tissue at this point there is some limitation of abduction of the ring finger.

The result 9 months after operation is shown in Figure 15, c, d, e. There is still a definite palmar nodule over the pretendinous band to the ring finger, but it does not interfere with the function of the hand.

CASE 26. (W. M. H. 138120) female, 44 years. Seven years before admission the patient cut the palmar surface of the left ring finger. Two years later a nodule appeared over the ulnar side of the palmar surface of the proximal end of the middle phalanx. Some time later flexion began and she became aware of a fibrous cord extending proximally to the web of the fingers (Fig. 45).

There was no history of past infection, or of similar trouble in other members of the family.

On May 9, 1928, under local anæsthesia, the digital fascia of the ring finger over the two proximal phalanges was carefully excised. The patient left the hospital 2 days after operation. The wound healed by primary union and when the patient was last seen, the finger could be completely extended without difficulty.

This case is the only one in our series in which the pathological process began in, and remained confined to, the fingers.

CASE 27. (W. M. H., 138251) male, 53 years, physician. Ten years before admission he noticed a contraction of the skin of the palm of the left hand in the line of the fifth finger, with beginning flexion

of the finger at the metacarpophalangeal joint. A little later the ring finger became involved. A year later a similar condition appeared in the right hand. The contraction developed very slowly until 6 months before admission when the contraction of the left fifth finger began to increase rather rapidly.

The condition of the hands before operation is shown in Figure 18, a, b, f, g.

The patient gave no history of trauma, or of infection other than an osteomyelitis of the left arm at 8 years of age.

On May 11, 1928, under local anæsthesia, an ellipse of hard, cornified skin and subcutaneous tissue was excised from the left hand, and the fascia at either side was dissected out as completely as possible. The defect left in the palm was filled with a free, full thickness graft of skin from the inner aspect of the left thigh. The nodule seen in Figure 18, a, in line with the outstretched thumb, was not excised because of the time consumed in caring for the major disability.

A part of the graft became necrotic, but epithelization took place fairly rapidly from the wound edges and the margins of that part of the graft which survived.

On June 4, 1928, under local anæsthesia, the contracted fascia of the right hand was excised through a transverse incision, and the wound closed without the aid of a graft. Some serum accumulated underneath the flaps and caused a serous wound discharge, and cellular infiltration developed in the involved area but healing took place without infection.

October 5, 1928, the patient wrote: "I have had and am still having, some trouble with the left hand, the one with the skin graft, cracking along the line of union between the skin and the graft. I thought it would be all right as it hadn't bothered for several weeks, but a few days ago another break showed. There is still some thickened skin on this hand, and I suppose that when it disappears there will be no further trouble. The sensation in this hand seems about normal, except at the inner side of the graft. The finger stays straight and I am able to use it without any particular trouble.

"I had quite a time getting the right hand healed up. For about a month after I returned home it kept opening near the center of the incision; it would heal for a few days, fill up with serum and open again. The last time it opened about one-third of the way between the incision and the base of the thumb. After this I put pressure on it with sea sponges, and it finally closed. It has been all right now for over 2 months.

"There is still a little infiltration in the palm of the right hand, but the sensation in the palm has never returned to normal. As near as I can describe it, there seems to be a superficial lack of sensation, or numbness, and a deep hyperæsthesia. In driving the car I have to wear a heavy pad in my palm; any pressure in the palm, even with a blunt instrument, such as a table knife, feels as though I were cutting my hand. I often look at it thinking I am holding the wrong end of the knife. I don't think there has been any change in sensation for the last 3 or 4 weeks. When I put my hand in hot water, there is no sensation of heat in the palm although I almost scald my fingers. I am able to use my hands well; my fingers are straight and I am able to make a good fist, but still find my fingers a little clumsy."

December 20, 1928, the patient stated that the sensory symptoms complained of were definitely less marked, and that he was able to use his hands more efficiently at his work as a nose and throat surgeon.

The appearance of the hands and range of motion of the fingers December 20, 1928, is shown in Figure 18.

Case 28. (W. M. H. 140735.) Male, 53 years, dentist. Two years before his admission to the hospital, the patient sustained an injury of the right palm from an automobile crank. There was a slight abrasion over the area subsequently involved in the contraction. Two months later he again sustained a slight injury of the same area from a screw driver. Four months later he first noticed a hard, tender lump under the palmar skin just proximal to the metacarpophalangeal joint of the ring finger. As the process progressed, a firm, thick cord developed which gradually drew the ring finger down to an angle of 160 degrees at the metacarpophalangeal joint. No other fingers were involved.

The patient had had appendicitis in 1915 and influenza in 1918. He had had a mild chronic pharyngitis for some years. No other members of his family had ever suffered from a similar condition.

October 3, 1928, under local anæsthesia, the superficial fibrous cord was excised, the skin at either side elevated, and the palmar aponeurosis excised as completely as possible. The wound healed by primary union. The patient left the hospital 6 days after operation, and because he felt he must return to his home in Iowa as quickly as possible no postoperative physical therapy was given. November 28, 1928, he wrote: "The swelling has almost entirely left the hand up to the fingers but there is still considerable swelling in the fingers and stiffness in the fingers and palm. The hand is also still partially anæsthetic."

December 16, 1928, he wrote: "I have just begun to use my hand the last week. The fingers are still swollen and the joints stiff. I have been wondering if radical manipulation of the fingers would cause more inflammation or aid in the recovery."

Needless to say we advised him that radical manipulation would do harm, but that every form of passive and active movement that could be accomplished without causing more than slight pain would aid in the restoration of function.

This case again pointedly illustrates the fact that without carefully directed postoperative physical therapy the patient is definitely handicapped in securing restoration of function in the shortest possible period of time.

CASE 29. (W. M. H. 140807.) Male, 46 years, physician. Twenty-three years before admission to the hospital the patient developed a callus of the right palm just distal to the metacarpophalangeal joint of the ring finger. A warty growth gradually developed at this point which was subsequently removed with an electric needle. The wound became infected, and in healing produced a cicatricial union between the skin and underlying tissues.

Six years before admission contraction gradually developed and within the 4 months immediately preceding his admission to the hospital developed rather rapidly (Fig. 46, a, b, c).

The patient had malaria in 1900, a gonorrhœal infection in 1908, a mastoid infection in 1913, and appendicitis followed by appendectomy in 1920. His tonsils were removed in 1918. He had had a sinus infection on two occasions and many "colds" before having his tonsils removed. No other members of his family suffered from a similar condition.

October 8, 1928, under local anæsthesia, the fibrous contracting cord was excised and the palmar and digital fascia carefully dissected away over as wide an area as possible. The digital branch of the median nerve going to the radial side of the ring finger was displaced ulnarward one-half the width of the finger by the contracting cord (Fig. 10) and before removing the fibrous tissue it was necessary to free the nerve of the fibrous tissue which completely surrounded it.

In this case because we were too conservative in the excision of the involved skin we failed to remove all the skin which was devitalized, with the result that a strip of skin about ⅛ inch in width gradually became black and eventually sloughed away. This process and the subsequent epithelization of the raw surface required a month's time. The patient left the hospital 5 days after operation, but healing was not complete until November 10, 33 days after operation. During this period he was frequently troubled with burning pain radiating down the affected finger, possibly due to the pressure of the dressing and sea sponge upon sensory nerve fibers exposed by the sloughing of the skin. The burning pain gradually disappeared as healing advanced.

The appearance of the hand and range of motion of the fingers 5 weeks after operation is shown in Figure 46, d, e, f.

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PRIMARY CARCINOMA OF THE LUNG[1]

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WITH the increasing accuracy of modern diagnostic methods, carcinoma of the lung is being recognized more frequently. Literature on the subject deals more with the pathological and roentgenological aspects than with the clinical, and an analysis of published data leaves the feeling that the bulk of the work concerns the late type of case, that which is ultimately proved by necropsy. In this article an attempt is made to segregate a group of early cases from among those observed in the Mayo Clinic since 1923 and in which the diagnosis was strongly substantiated; in more than half the cases the clinical diagnosis was confirmed microscopically.

Adler, in 1912, reviewed all the previously ill-assorted literature on primary carcinoma of the lungs, and published an excellent monograph in which 374 cases were tabulated. Few data of value have been added since, except from the roentgenological point of view. Recently, Fried published a critical analysis of 10 cases, Eloesser of 27 cases, and Grove and Kramer an exhaustive pathological study of 24 cases. Many other writers have published smaller groups of cases, but almost invariably on necropsy data. Eloesser brings out, but does not emphasize, a division into two groups, bronchial and parenchymal. The cases in this series are divided into three groups: bronchial, parenchymal, and late (Table I).

Group 1. The bronchial "proved" cases consisted of those in which the lesion was demonstrated by bronchoscopy and proved by microscopic section taken through the bronchoscope. In the "probable" cases of this group either the lesion, as seen through the bronchoscope, was typical, or metastasis was found with a bronchial lesion as the only primary focus discoverable.

Group 2. In the parenchymal "proved" cases lesions were demonstrated in the lungs roentgenologically and carcinomatous nodes were found in the neck, although there was no clinical evidence of abdominal malignancy. These data, although not absolute proof, are strongly suggestive of pulmonary malignancy. The "probable" cases comprise those in which the history and roentgenograms indicate malignancy and in most of which it was ascertained that death occurred within a reasonable time after this provisional diagnosis had been made.

Group 3. In the late "proved" cases, whether apparently bronchial or parenchymal, the diagnosis was made at necropsy and in the "probable" cases there was clinical evidence of malignancy; repeated tapping was carried out for extensive pleural effusion and the fluid withdrawn was of the sanguineous type commonly associated with malignancy of the lung.

The manner in which the early proved cases fell into two groups, according to the site of the section for biopsy, brings out a point that should be emphasized; namely, that there are in the early stage two distinct types of carcinoma of the lung, the bronchial and the parenchymal. The clinical data fall into like groupings, a point apparently not hitherto realized.

As seems usual in the discussion of carcinomatous lesions, the etiology has received considerable attention. Many factors have been discussed, varying from the perennial hypothesis of chronic irritation to the possibility of inhalation of dust from tarred roads. Influenza has been suggested as accountable for the apparent increase in malignancy of the lung. Of the 68 patients in this series, 20 gave a history of previous influenza or acute respiratory disease other than tuberculosis and none

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of known tuberculosis. While the incidence of influenza is not low it is probably not higher than that of this disease in general, considering the universality of the recent pandemics.

The ratio incidence in male and female is 5 to 13; our data thus agree in general with those of other reported groups of cases. Certain persons support the hypothesis of chronic irritation on the basis of this preponderance of males. The age incidence is much as usual (Table II).

The history of the duration of the disease and survival of patients after diagnosis is made is illustrated in Table III, which shows that the disease is usually a rapid process.

TABLE I.—GROUPS

Type	Proved cases	Probable cases	Total cases
Bronchial	13	10	23
Parenchymal	10	12	22
Late	10	13	23
Total	33	35	68

TABLE II.—AGE INCIDENCE

Age	Bronchial	Parenchymal	Late
Under 30	2	1	..
30 to 39	4	2	3
40 to 49	6	7	11
50 to 59	7	8	6
60 to 69	4	4	2
70 and over	..	..	1

TABLE III.—DURATION OF DISEASE

Time, months	Bronchial	Parenchymal	Late	Total cases
Duration of disease before diagnosis				
Less than 3	6	4	3	13
3 and less than 6	6	5	5	16
6 and less than 12	6	9	8	23
More than 12	5	4	7	16
Total duration of disease (where death was ascertained)				
Less than 6	..	2	4	6
6 and less than 12	8	9	6	23
12 and less than 18	..	6	6	12
More than 18	3	1	..	4

PATHOLOGY

Macroscopic lesions are seen only at necropsy, and then only in the late stages, so that the primary lesion is often more or less obscured. Generalized lymphatic or systemic metastasis, a thick, dense, empyema-like pleura, or extensive pneumonitis was present at necropsy in all of the late "proved" cases of this series. A generally accepted gross pathological subdivision of lesions is somewhat as follows: (1) nodular (single, multiple); (2) lobar or diffuse; (3) infiltrating, and (4) miliary.

The nodular and lobar types (reasoning from the roentgenological picture of the early parenchymal group) are merely different stages of one type. The best example of the true nodular type may be seen in Figure 1, which shows how the typical round nodule of the roentgenogram is produced.

The infiltrating type includes all bronchial tumors and certain parenchymal tumors the foci of origin of which being near the hilum, invade it relatively early. Figure 2 shows the gross appearance of an advanced case of bronchial tumor.

The so-called multiple nodular and the miliary types are probably entirely metastatic and not actual types of primary lesion.

In order to group the microscopic data, an attempt was made in the necropsy cases to determine the original focus. Five of the ten cases were apparently bronchial in origin; all of these five showed emphatically the frequency of atelectasis distal to the lesion, a point also noted roentgenologically.

Ewing early called attention to three foci of origin: (1) bronchial epithelium (bronchogenetic), (2) bronchial mucous glands (bronchogenetic), and (3) flat epithelium of lung alveoli (alveolar). Although this grouping is quoted in the literature almost consistently, actually it is extremely difficult to correlate the cell groupings, as found, to these particular foci.

Grove and Kramer and, later, Eloesser stressed a classification according to cell type. In Table III is given such an analysis of the type of tumor found in each of the microscopically proved groups. In so far as the number of cases is sufficient to justify tenable deductions it would appear that while any type of tumor may be found in the bronchus, the parenchymal tumor is either an adenocarcinoma or of the highly undifferentiated type and rarely an epithelioma. The epitheliomata seem to be almost entirely confined to the bronchus.

Adenocarcinoma has no characteristics peculiar to the lung. The tumor is of a simple glandular type resembling a mammary or

Fig. 1. Irregular nodular area of parenchymal carcinoma in lower lobe of lung (microscopically adenocarcinoma).

Fig. 2. Advanced carcinoma of the bronchus just below the bifurcation (microscopically epithelioma).

prostatic tumor (Fig. 3). Among the adenocarcinomata were two of a markedly papillary type, forming a peculiarly distinct subgroup, the significance of which we do not know. There was no indication that they were metastatic from the thyroid or the ovary, although they resembled the typical papillary tumors of those organs.

The undifferentiated type was formerly called medullary and, as such, was noted by Adler as a common type of tumor of the lung. It may sometimes be so highly cellular as to resemble sarcoma (Fig. 4). In the absence of differentiation, it is difficult to classify this tumor as either adenomatous or squamous; it might truly be called "carcinoma, highly malignant."

The squamous cell tumor (Fig. 5) is anomalous in that it appears where there is no squamous epithelium; various hypotheses are advanced to explain this. It has been suggested that the tumor originates in scar tissue, but it is generally believed that it arises from true metaplasia, with reversion to a fetal type of cell. The respiratory tree, it will be remembered, arises from a diverticulum of the foregut in common with the œsophagus, a squamous cell lined canal.

Broders, in his gradation of tumors according to what might be called "the virulence of the type of cell," shows that the less the differentiation in the cell type the more the virulence of the growth. We graded our sections according to Broders' scheme (Table IV). The

TABLE IV.—HISTOLOGY

	Cases, grade of malignancy				Bronchial		Parenchymal	
	1	2	3	4	Bronchoscopic biopsy, cases	Necropsy, cases	Gland of neck, biopsy, cases	Necropsy
Squamous cell epithelioma		1	3	6	6	2	2	
Adenocarcinoma	1	1	3	7	4	1	6	1
Undifferentiated carcinoma				11	3	2	2	4
Total	1	2	6	24	13	5	10	5

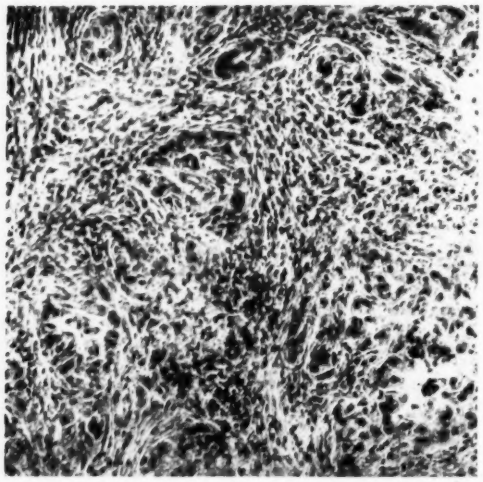

Fig. 3. Adenocarcinoma from parenchymal carcinoma of the lung. (×120.)

preponderance of a highly malignant type of tumor shown in this table is consistent with the frequent early metastases and the average short history. It also bodes ill for any attempts at treatment.

ROENTGENOLOGICAL FEATURES

Roentgenologists have for a considerable time recognized two types of carcinoma of the lung. Carman reported a group of 37 cases, of which he classified 23 as of the hilum. Other articles, especially those recently written by Christie and by Wessler and Jaches, bring out this subdivision of roentgenographic types, but without correlation with the clinical picture.

It has been the custom to subdivide the parenchymal group into nodular and lobar types. We believe that the true parenchymal carcinoma always begins as a single nodule. Figure 6 illustrates what we consider to be an early lesion, although a diagnosis at this stage can rarely be made. From this stage it may grow, confined to a single lobe, to become the so called lobar type (Fig. 7), or may become merely an irregular mass without typical localization (Fig. 8). Again, the type may occur which, according to Carman, gives the only pathognomonic picture, that of a primary mass with distal metastasis, like satellites of the parent tumor (Fig. 9). The dominant appearances found in our roentgenograms may be noted in Table V.

TABLE V.—ROENTGENOGRAPHIC APPEARANCE

Roentgenographic appearance of parenchymal carcinoma of the lung	Cases
Single nodule	7
Nodule with satellites	1
Lobar distribution	6
Some fluid	4
Irregular mass	3
Miliary, primary not showing	1
Roentgenographic appearance associated with bronchial carcinoma	
Atelectasis only	6
Atelectasis and density of hilum	5
Density of hilum only	6
Density of hilum and bronchiectasis	3
Bronchiectasis only	2
Density of hilum, atelectasis and bronchiectasis	1

In the bronchial type of tumor the symptoms are clear cut but lack the definite roentgenological picture of the parenchymal type. It has been said that bronchial tumors cannot be diagnosed roentgenologically. Certainly a defined mass in the hilum is by no means universal, as this means that the lesion has extended beyond the bronchial wall. The presence of a mass can be demonstrated, however, in a certain percentage of cases. The tumor is unilateral, is centered accurately at the hilum, with its edge infiltrating lung tissue; the latter distinguishes it from enlargements of the hilum glands. Figure 10 represents such a type.

Actually, however, the more constant sign of bronchial malignancy is the evidence of atelectasis of a lobe or part of a lobe produced by bronchostenosis. This is not evidence essentially of malignancy, but after the elimination of foreign bodies there are few lesions that would give such a shadow without themselves being visible in the roentgenograms. We noted such atelectasis in many forms (Figs. 11 and 12). Roentgenological manifestations of atelectasis are collapse of the ribs, elevated diaphragm, displaced trachea, and, especially, the peculiar homogeneous, increased density of the atelectatic lobe.

The least common of the roentgenological signs is the presence of apparent bronchiectasis. This is produced by partial obstruction, and filling up below with blood and secretions (Fig. 13). The incidence of these data in our series is summarized in Table V.

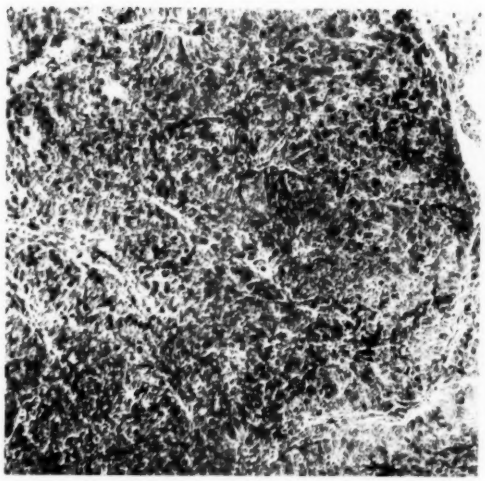

Fig. 4. Highly undifferentiated carcinoma from a carcinoma of the bronchus. (×120.)

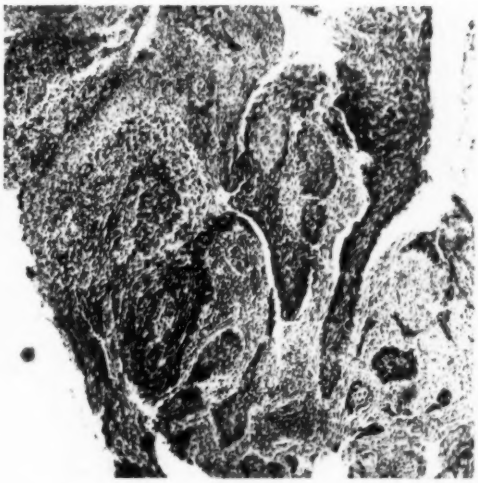

Fig. 5. Squamous cell epithelioma from carcinoma of the bronchus. (×60.)

The roentgenological picture in the late case of carcinoma of the lung varies. More than half the cases show only fluid, one lung field being solidly dense up to the apex and with the heart displaced to the other side. Again, any of the protean forms of infection may be manifested secondarily. Rarely there are large tumors not concealed by fluid. One of our cases presented the picture of pure multiadenopathy of the mediastinum due to lymphatic involvement from carcinoma of the bronchus, but the lung fields were not affected; from such a picture lymphoblastoma would inevitably be diagnosed.

CLINICAL CONSIDERATIONS

The dominant symptoms of carcinoma of the lung are generally given as pain, cough, sputum, hæmoptysis, loss of weight and dyspnœa, but a really typical syndrome has not been described. If, however, we consider that in the early state there are two separate entities, the clinical picture of each becomes much more constant. The various symptoms in degrees of severity have been tabulated separately for each group (Table VI).

In the bronchial group, cough is the key symptom. While not necessarily severe or even unduly troublesome, it has one definite characteristic, persistency. Sputum is seldom profuse and never foul until late in the course of the disease. It often contains blood, either frank hæmoptysis, or, more often, is constantly blood-tinged. Considerable loss of weight is relatively constant. Pain is usually present, but seems to be less complained of than the cough. Dyspnœa occurs but generally indicates some pleural effusion. Physical examination usually indicates the presence of bronchostenosis.

There is one almost certain means of diagnosis in these cases, the use of the bronchoscope. This, however, is worse than valueless in the hands of the inexperienced. While some ulcerations appear malignant, others show merely a red, granulating, bleeding surface which is identified only by microscopic examination of the biopsy section.

In summarizing it may be said that, in an elderly patient, a peculiarly persistent cough, associated with scant but usually blood-stained sputum and with considerable loss of weight suggests bronchial malignancy.

The symptoms of the parenchymal group are not so clear-cut (Table VI). The tabulated data, however, fail to bring out a point realized only by the individual study of cases, namely, the marked degree of latency. In

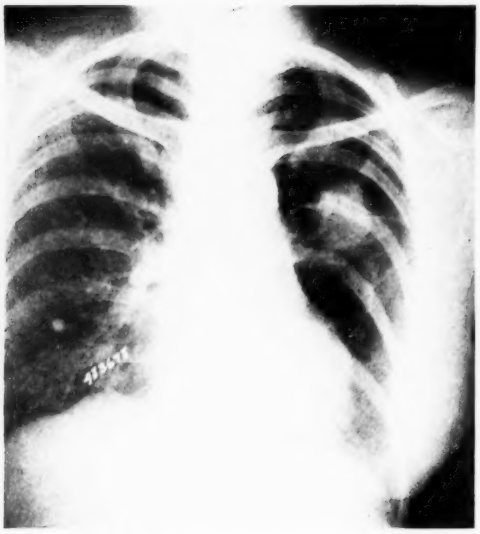

Fig. 6. Nodular primary parenchymal carcinoma in a case in which metastatic brain tumor (adenocarcinoma) was found at operation.

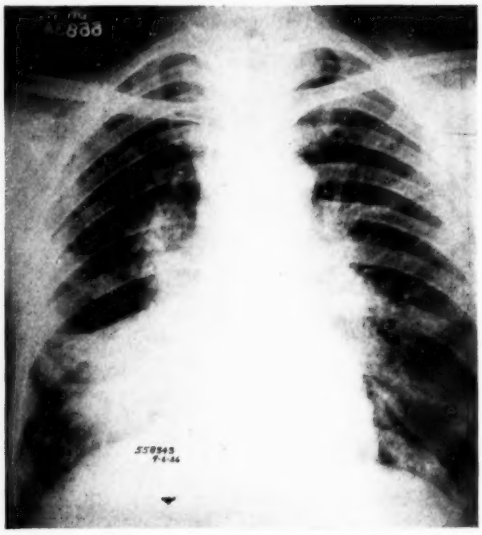

Fig. 7. Primary lobar carcinoma of the lung. Biopsy of cervical lymph nodes showed epithelioma.

many of the cases there is little emphasis on the symptoms. The lesion is deep and until it involves either a bronchus or the pleura, it gives no evidence of its presence. Loss of weight is the most constant sign, often without much apparent cachexia or symptomatic loss of strength. Pain is the most constant of the symptoms and it has certain peculiar characteristics. It is vague, in the chest, difficult to localize, never sharp, seldom intermittent, sometimes substernal, but more often posterior in the scapular region, or even described as "right inside." Mild at first, it becomes gradually more severe. This characteristic type of pain is not the same as that felt later when the chest becomes full of fluid or that produced by cough, and this "early" pain is likely to be masked later by the dominance of other symptoms. We found it usually associated with, and apparently relatable to, the nodular type of lesion. Cough relates to one of two processes: involvement of the pleura as evidenced by fluid, or, more often, invasion of a bronchus. As with the bronchial type, it may produce blood. At this stage the lesion may be demonstrable through a bronchoscope but more often the bronchus is bulged inward, without actual ulceration of the mucous membrane. Dyspnœa is infrequent and practically always indicates an appreciable accumulation of fluid.

TABLE VI.—SYMPTOMS

Symptoms	Marked	Definite	Slight	Absent
Bronchial carcinoma (twenty-three cases)				
Cough	12	8	3	..
Sputum	2	7	7	7
Blood in sputum	2	8	5	8
Pain	2	3	9	9
Dyspnœa	1	2	9	11
Fever	..	2	9	12
Loss of weight[1]	9	6	3	5
Parenchymal carcinoma of the lung (twenty-two cases)				
Cough	2	9	6	5
Sputum	..	1	9	12
Blood in sputum	..	9	..	13
Pain	11	3	3	5
Dyspnœa	4	4	6	8
Fever	..	2	4	16
Loss of weight	3	12	5	2
Late carcinoma of the lung (twenty-three cases)				
Cough	4	8	6	5
Sputum	2	5	6	10
Blood in sputum	..	6	..	17
Pain	2	6	5	10
Dyspnœa	10	3	6	4
Fever	3	4	3	13
Loss of weight[1]	9	5	6	3

[1] Slight, under 10 pounds; definite, 10 to 29 pounds; and marked, 30 pounds and over.

Fig. 8. Massive parenchymal carcinoma of lung. Generalized metastasis was found at necropsy.

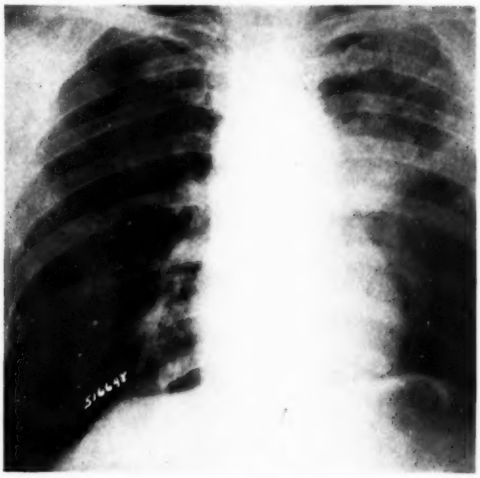

Fig. 9. Nodular tumor with smaller metastatic areas in the apex peripheral to it. No other primary tumor was found.

Another sign is of value: the presence of metastasis in the supraclavicular nodes. This occurs with such extraordinary frequency that we have used it as evidence to isolate our group of proved early cases. Physical examination is inconclusive and often negative.

The disease tends to a rapid course and does not long remain an uncomplicated malignant lesion. With extension the two types fuse to a common type which we have classified as "late cases." In this group symptoms were dependent chiefly on the dominant secondary complication; their tabulation (Table VI) affords a contrast with their incidence in the other two groups. The cough-blood syndrome and the pain are still present but the most prominent feature in this group is the extent of the dyspnœa which can be almost constantly related to the presence of fluid.

Pleural effusion is the most common method of extension. In the entire group of 68 cases, early and late, there was evidence of fluid in 23. This was of the malignant type, that is, thin, blood-stained fluid which rapidly reaccumulates after tapping, and the presence of which is easily recognized clinically and roentgenologically. In all of the "probable" late cases roentgenograms showed the entire lung completely dense from base to apex. Simple effusions due to root lymphatic obstruction and infective effusions, do occur, but rarely.

Infective processes follow either necrosis in the center of a parenchymal tumor, or stasis consequent on bronchial stenosis. This will so complicate the picture both roentgenologically and clinically as to render the diagnosis of other than the infective process impossible except when there are demonstrable nodes, or bronchoscopy is performed.

Metastatic extension is the other common end-stage. The early incidence of cervical gland involvement has been noted. In a discussion of the roentgenographic features a case of advanced mediastinal metastasis was cited. A notable feature is the frequency of metastasis to the brain as the first evidence of a lesion: in others it is the terminal phase. In this series there were 6 cases of metastasis to the brain; this feature was also noted by Parker. Another interesting evidence of extension was recurrent laryngeal involvement in seven cases.

DIFFERENTIAL DIAGNOSIS

An exhaustive discussion of differential diagnosis would enumerate practically every known lesion of the lung. The two main dis-

Fig. 10. Defined mass in the hilum caused by a bronchial carcinoma (epithelioma) seen on bronchoscopic examination.

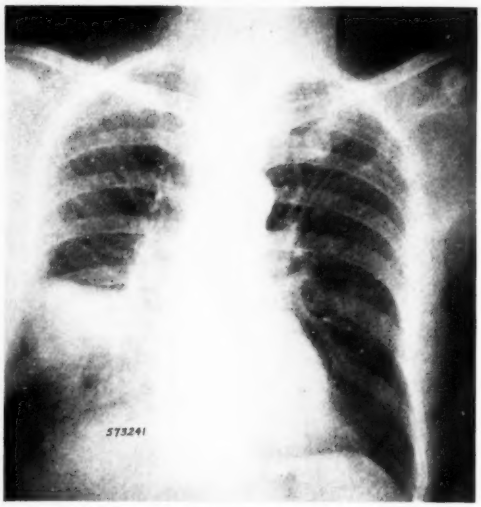

Fig. 11. Atelectasis of the middle lobe caused by a bronchial carcinoma (highly undifferentiated type) seen on bronchoscopic examination to involve the middle lobe bronchus.

cases to be differentiated are tuberculosis, which is likely to be confusing from the clinical standpoint, and infective conditions, which are often mistaken from the roentgenographic standpoint. Tuberculosis is important in that so many patients afflicted with pulmonary malignancy waste time, hope, and money in sanatorium treatment. In such cases the roentgenogram is the chief diagnostic medium. A tuberculous lesion tends to apical distribution and malignancy to the middle region. Tuberculosis is an irregular, peripheral lesion with no distinct center, while malignancy, whether parenchymal or in the hilum, has an obvious center and radiates. Clinically, the history is longer, sputum is more abundant, and, sometimes, the presence of tuberculosis bacilli in the sputum makes the diagnosis certain. The roentgenographic differentiation of malignant from infective conditions (abscess, bronchiectasis, and old lesions of pneumonia), on the other hand, is by no means easy, but the clinical features are not similar. With infective conditions there are periods of acute exacerbation and often sputum is abundant. The age is also often a helpful factor. In this connection the incidence of leucocytosis in the malignant cases was tabulated. Of the 45 cases in the early groups, only 10 showed a leucocyte count of more than 10,000, and in 7 of these the patients actually had fever from infective complications. If these two factors could be safely eliminated but few others would remain which the correlation of clinical with roentgenographic data would not easily distinguish.

In the bronchial group the bronchoscope is the final court of appeal. In the parenchymal group, unfortunately, observation is the only ultimate means of making a diagnosis; steady growth or cervical metastasis will confirm a suspected diagnosis of malignancy. In the late group there is seldom any doubt.

SUMMARY

In the early stages, carcinoma of the lung may be divided into two types, with clinical and roentgenological entities: (1) bronchial, arising in the wall of a first to third degree bronchus, and (2) parenchymal, arising in the substance of the lung.

In the bronchial type there is a history of early chronic persistent cough, not greatly productive but often associated with hæmoptysis or blood-tinged sputum. Usually there is loss of weight. Unilateral infiltrating den-

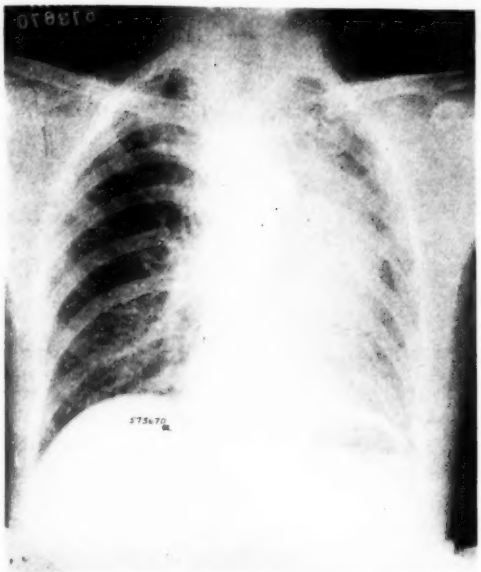

Fig. 12. Commencing atelectasis of the whole lung caused by a bronchial tumor seen on bronchoscopic examination to be occluding the left main bronchus.

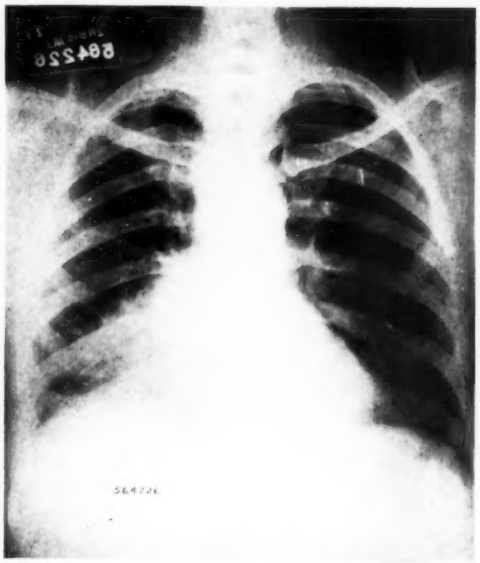

Fig. 13. Appearance resembling that of bronchiectasis, without any clinical evidence of such, caused by a bronchial carcinoma (epithelioma) of the lower lobe bronchus.

sity at the hilum is seen in the roentgenogram in some cases, but more constantly atelectasis of a lobe due to bronchial obstruction is seen.

The parenchymal tumor is more latent, but there is definite loss of weight and a peculiarly ill-localized type of pain in the chest. Later the bronchus may become invaded, in which case the lesion resembles the bronchial group. In the roentgenogram it is seen as a round nodule with infiltrating edges and lying free in lung tissue. Later it involves the whole or most of a lobe.

In the later stages the two types tend to a common type and the actual malignancy is obscured either by pleural effusion or by infective processes. This is associated with dyspnœa or the usual evidences of infection.

Pathologically our analysis seems to show that the parenchymal tumor is usually an adenocarcinoma, that the bronchial tumor may be either adenocarcinoma or epithelioma, the epitheliomata being practically confined to the bronchus, and that the lesion is of a high grade of malignancy.

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ARTIFICIAL INSEMINATION BY WAY OF THE OVARIAN BURSA IN THE GUINEA PIG[1]

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THE conception that led up to the experiments reported in this paper was that of injecting spermatozoa into the peritoneal cavity with the idea that some of them might be attracted to the region of the ovary and fertilize ova there. The difficulty of obtaining from small laboratory animals a quantity of sperm sufficient for injection could not be satisfactorily overcome. The viability of spermatozoa in warm Locke's solution or other media might be sufficient to get live sperm into the peritoneal cavity, but how long they would survive there was problematical. Therefore, it was determined to apply sperm directly to the surface of the ovary and at such a time that impregnation would be most likely to occur.

It has been shown that guinea pigs copulate only during the first stage of œstrus (5). Within a comparatively short time after copulation large numbers of spermatozoa have reached the ovarian bursa and await the bursting of the graafian follicles, which does not take place until the end of the second stage of œstrus (that is, at the junction of stages 2 and 3). So with one exception we used only females with first stage vaginal smears. Operations were performed for the most part on the days when male guinea pigs were killed for complement, so as to avoid any unnecessary sacrifice of animals in obtaining sperm.

DESCRIPTION OF METHOD

In our colony the males and females are isolated; there are as a rule two animals to a cage. A student assistant in charge of the animal records takes smears each day from those females with open vaginas. During this work smears reported as first stage were checked and if satisfactory, the animal was used. One female was used in stage 3 and note of this fact is made in Table I.

A suitable operating board was prepared, having a contour slightly convex upward in the middle. The animal was fastened abdomen downward on this board and the hair removed from the two operation sites. These lay in the angle between the last rib and the spinal column on each side. The hair was clipped close with scissors and the remainder removed with sodium sulphide. The skin was prepared with iodine and anæsthesia was begun.

In anæsthetizing guinea pigs, it is advisable to use a device similar to that pictured here (Fig. 1), so that only dry ether vapor reaches the nostrils of the animal, for otherwise postoperative pneumonias are apt to be frequent. This apparatus is modelled after that used at Cornell University Medical School by Dr. G. N. Papanicolaou. A Mohr's pinchcock is helpful in regulating the outflow of the gas, as the rubber bulb can be inflated to a considerable degree and the escape of air from it into the ether bottle thus made as fast or slow as desired. This is especially desirable after the animal is fully anæsthetized.

Aseptic precautions were employed in the operations. Sterile towels and sponges and sterile instruments insured a minimum risk of infection, and it is noteworthy that no infections occurred. The personnel consisted of surgeon, assistant surgeon, anæsthetist and general assistant. The last acted as nurse and also helped in dissecting the freshly killed males to obtain sperm.

An incision about 1.5 centimeters long was made on each side and the ovary was exposed by extruding it through the slit in the peritoneal bursa. It was then inspected to determine the number of ripe follicles present; after this it was dropped back in place and a hot sponge was laid on the wound. This was accomplished on both sides before the males were sacrificed.

As soon as the male was bled (for complement) or if sacrificed only for the experiment,

[1] Contribution No. 2, Series B, from the Department of Anatomy, Medical Department, University of Georgia. This work has been aided by a grant from the National Research Council through its Committee for Research on Problems of Sex.

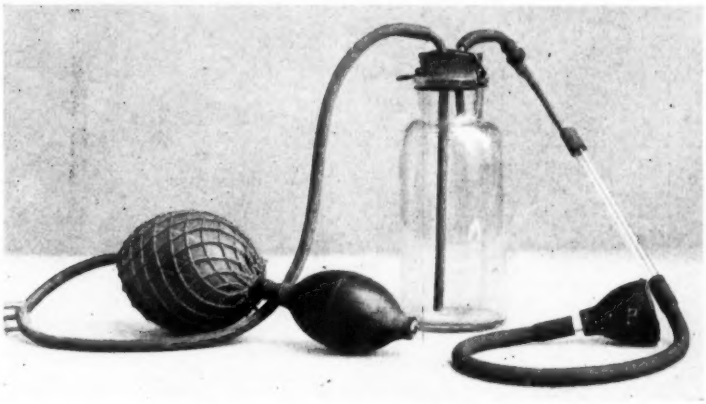

Fig. 1. The anæsthetizing apparatus. *A*, Bottle for ether; *B*, half of old rubber bulb with air-holes punched in sides for use as nose-piece.

as soon as dead, the abdomen was opened and the vas deferens exposed from the testicle to the prostate. Each vas was now caught at the proximal (testicle) end by a small hæmostat and dissected free. One hæmostat caught both the distal (prostate) ends and the whole was rapidly excised and removed to the operating table. The hæmostat at the distal end was now snipped off and with a pair of forceps the sperm from both vasa was stripped out simultaneously upon a sterile, dry glass slide. Two or three large drops were usually obtained in this way.

The ovaries were now exposed again in turn, extruded from the sac and the sperm was taken up on the end of a scalpel and smeared over the whole organ, which was immediately returned to its place.

Two layers of sutures now completed the operations, one layer of two or three sutures in the muscle and one of three or four in the skin. Round needles were used for the muscle, but good quality Keith needles are needed for guinea pig skin, which is unusually tough. No. 0 or 1 plain catgut was the suture material.

In some cases, sperm from one male was used on one ovary and sperm from another on the opposite one. This was usually the case when sperm was obtained from the males killed for complement, since more than one was always sacrificed for this purpose. Successful insemination on each side by this method would result in young born at the same time having different fathers.

The animals as a rule recover from the anæsthetic within 3 or 4 hours or less and thence on behave just as if nothing had happened.

RESULTS

The œstrous cycle in the guinea pig averages about 15½ to 16 days (5). Animals operated on were watched carefully for the return of œstrus. This is very easy in the guinea pig, since the vaginal orifice actually grows up between heat periods and during pregnancy (3). As long as the vagina is thus closed the animal is not in œstrus. If it does not come back into œstrus at the expected time, the next step is a vaginal curettage at 3 weeks after the operation. By this time the vaginal mucosa, if pregnancy has supervened, has undergone a change to a high columnar mucous epithelium. These cells when scraped out are characteristic, and within certain limitations are diagnostic of pregnancy in this animal (2). The third test for pregnancy is palpation. This is usually applicable by the fourth week or a few days earlier and is a positive test for one with practice in performing it. Table I shows the results in condensed form.

In spite of the fact that animals No. 1033 and No. 1057 did not return to œstrus after

TABLE I.—RESULTS

Number	Operation	Side	Return to Heat	Vaginal curettage	Palpation	Delivery	Young
1033♀	3–26–28	Both		4–17–28 Positive	Positive	6–3–28	Two
1029♀	4–16–28	Both	5–5–28				
1057♀	4–23–28	Left		5–14–28 Positive	Positive	6–3–28	Abortion
1010♀	5–3–28	Both		5–25–28 Positive	Positive	7–10–28	Two
1009A♀	5–5–28	Both		5–26–28 Positive	Positive	7–13–28	One
1026*♀	5–5–28	Both	5–19–28				
1007♀	5–15–28	Left	5–31–28				

*Stage 3. All others operated on in stage 1.

Fig. 2. Animal No. 1033 and her two offspring, the first we obtained by this method.

insemination and also were definitely pregnant according to the vaginal curettage test and palpation, it was feared that abortion might cause the loss of actual evidence. Therefore, we decided to expose the uterus in each case and see what it held.

No. 1033 was operated on May 1, 1928, and the right uterine cornu exposed. One fetus was discovered. This animal gave birth on June 3rd to two young (Fig. 2), one agouti, like herself, and one black, white, and red. It is probable that one young came from the left cornu and had a different father, as two males furnished the sperm for the insemination. On the other hand, there may have been two fetuses on the right side and the cornu not pulled out far enough at the operation to show both.

When No. 1057 was inseminated, the right ovary could not be located and sperm was placed only on the left side, where, fortunately, three ripe follicles were seen. At operation three fetuses were discovered in the left uterine horn. The incision was rather small and some difficulty was experienced in replacing the enlarged uterus in the abdominal cavity. No doubt the young were injured, as the mother aborted six days later.

It is interesting to note that No. 1009A was only 3½ months old at the time of operation and that she was inseminated at her fourth œstrus. She is still a very small animal compared with most of the others used.

The incidence of successful impregnation, omitting No. 1026, which was operated on in the third stage (that is, after ovulation), is 66⅔ per cent. This compares very favorably with natural insemination, which probably does not exceed 90 per cent.

It is worthy of note that we tried this method in white rats in more than twice as many cases as in guinea pigs and got no positive results. The rat has a complete bursa ovarica, which separates the ovary entirely from the peritoneal cavity (4). Rupturing this sac always caused considerable hæmorrhage. Injection of sperm into the bursa from a small tuberculin syringe with a fine needle or from a capillary pipette with a rubber bulb was not successful. Moreover, in rats the sperm was not usually soft, milky, and free-flowing as in the guinea pig, but appeared inclined to a more solid, lumpy consistency.

DISCUSSION

Whether these findings have any clinical significance is problematical. If human sperm could be obtained in aseptic condition and the exact time of ovulation foretold in woman, it is probable that successful impregnation could be accomplished by this method in some cases where laparotomy was necessary for some other purpose.

This method opens an avenue of investigation into the behavior of spermatozoa in relation to the ovum and to the uterine tube. While the only animal we tried to inseminate in stage 3 did not become pregnant, the same

is true of two others in stage 1. By inseminating a sufficient number of animals in stage 3, one, two or three days after it starts, possibly some pregnancies would occur. Since the ova require about 4 days to reach the uterus and are in the tube during this interval, successful insemination would mean that spermatozoa went down the tube instead of coming up, as they usually do. This might be held to prove an "ovotropic" influence in the mammalian ovum. It is significant that spermatozoa in the guinea pig can reach the bursa ovarica and teem in large numbers around the ovary in less than 2 hours after copulation, whereas it requires 4 days for the combined ciliary motion and peristaltic movements of the tube to carry the much larger ovum less than the distance traversed by the male germ cells. If the extremely small spermatozoa depended upon reverse peristalsis for their progress through the tube, as has been claimed, how long would it take for them to reach the ovary?

It is worthy of note that all the young born in this series went longer than the usual term by 2 or 3 days, viz., 68 days in one case and 69 in two. Whether the effects of the operation cause a delay in the early progress of the ovum we cannot say.

Whether it may be possible by this method to produce hybrids between animals that will not or can not naturally copulate, will have to be determined.

A careful search of the literature does not reveal any work similar to this, with one exception (1). Kampmeier injected spermatozoa of the dog into graafian follicles of the bitch; but his purpose was not the same as ours, as he was making a study of early changes in the ovum.

SUMMARY AND CONCLUSIONS

1. Artificial insemination by way of the ovarian bursa in the guinea pig can be accomplished in about two-thirds of the trials, if the females are selected during the first stage of œstrus and a suitable technique is employed.

2. The young born are normal in every way and thrive just as the progeny of natural insemination.

3. It is possible by this method to produce young born at the same time from one mother but with different fathers.

4. This method opens up a new pathway of investigation into the behavior of the spermatozoa in relation to the ovum and to the uterine tube.

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MALIGNANT AND SEMIMALIGNANT TUMORS OF THE OVARY

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FOR the study of the malignant tumors of the ovary, the pathological reports of the Gynecological Division of the Roosevelt Hospital were reviewed from the beginning of the year 1910 until the end of 1927, and all cases with the diagnosis of papillary cystadenoma, primary carcinoma of any variety, and sarcoma were selected, and the pathological sections re-examined as far as possible. That each of these varieties should be included in the complete survey was necessary because of the extreme variation in interpretation placed upon these terms by various surgeons and pathologists. Tumors considered by the operator or pathologist as being probably metastatic in the ovary have been omitted, although it is possible that a few such secondary tumors have slipped into the series, since the exact localization of the primary focus in the more advanced cases is often very difficult.

The total number of cases originally included was 152, of which 13 were entirely without biopsy or had been diagnosed from cells obtained by centrifugalization of ascetic fluid, the diagnosis, therefore, being open to question. These cases were excluded.

Of the remaining 139 with complete pathological reports, the sections of 17 had subsequently been lost and were, therefore, incapable of standardization. These cases have not been used except in the final summary of end-results, since their finer histological characteristics are in doubt.

That a detailed pathological description is essential to any clinical report of the end-results in ovarian tumors was most conclusively demonstrated to us in the study of the heterogeneous group of cases that had been ascribed to the papillary cystadenomata. In general, the tendency in earlier years had been to include practically all carcinomata except the glandular and solid varieties in the papillary adenoma group. In the later years, on the other hand, the carcinomata appear to have been more logically placed, while many tiny tumors of a faintly papillary form, but of a more adenofibromatous histology had been added to the papillary cystadenomata. That clinical reports of such heterogeneous material is useless, is self-evident, and we are, therefore, reporting results on numerous small groups and later summarizing as far as consistency permits.

CLASSIFICATION

The origin of the cells that form the ovarian tumors has been a disputed point since the first studies in cellular pathology. All observable epithelial structures found in the adult ovary, in the ovary of the embryo, and in neighboring embryological structures, such as the muellerian and wolffian ducts, have been successively held responsible. The history of the earlier research into the origin of ovarian tumors is an interesting one, though based almost exclusively upon morphological studies and for the moment of little value in the understanding of present theories.

Robert Meyer (41), in 1916, in an almost classical study, reviewed most of this earlier work and gave a histogenetic classification of ovarian tumors. This work followed rather closely the morphological divisions of Pfannenstiel (56) but made certain changes in an attempt to emphasize genetic relationships. Meyer derived all ciliated epithelial tumors from the germinal epithelium, whether this be in the form of the surface epithelium of the adult ovary or in that of remnants of the medullary rays or rete ovarii, while to the pseudomucinous tumors he tentatively ascribed a teratomatous origin.

The probability that many if not all ovarian tumors had as their origin the surface epithelium, had for some time before Meyer's article been indicated by the discovery of ciliated epithelium on the surface of the ovary and by the tracing of cords of cells down into ciliated cysts near the surface (de Sinéty et Malassez, 72; Flaischlein, 13; Walthard, 77; Pfannenstiel, 55). On the other hand, the

belief that tissue of extra-ovarian origin, particularly in the form of wolffian remnants, played an important part in the formation of ovarian tumors, was championed by von Recklinghausen (59) and long remained a popular rival of the germinal epithelium theory, but it appears now to have been eliminated by the extensive studies of Goodall (19, 20) in comparative embryology published in 1912 and in 1920, in which he demonstrated that the tubules of the wolffian body once thought to invade the ovary during fetal life never do so, but are met outside of the ovary by tubules growing down from the ovarian cortex. The theory that pseudomucinous cysts are merely the overdevelopment of the entodermal component of a teratoma had been originally proposed by Hanau (24) in 1898, had received strong support from Ribbert (60), and had been in part accepted by Pfannenstiel (56), in the sense that he considered these tumors as arising from the follicle epithelium. It was chiefly opposed by two theories, the first of which maintained that ovarian cysts were frequently derived from muellerian duct rests and the pseudomucinous varieties were showing a development in the direction of that part of the muellerian duct which forms the mucous glands of the cervical canal (Kossmann, 28, 29), while the second asserted that the germinal epithelium with the aid of its facility for metaplasia could be transformed even into goblet cells. The latter theory rested partly on Walthard's (77) work in which he had shown the presence of goblet cells in small islands in many otherwise normal ovaries, a study supported by Lahm (32) and others, but recently called in question by Richter (61). In general, however, it may be said that in 1920 it was a prevailing belief that ovarian tumors were all ovarian in origin, the serous, ciliated tumors coming directly from the germinal epithelium and the pseudomucinous from the germinal epithelium either by a short process of metaplasia or the longer one of passing through the ovum stage and being ovulogenic, that is to say, teratomatous in origin.

Sampson's (64) first paper in 1921 on endometrial implants in the ovary and peritoneum with its ingenious theory of their origin and its demonstration of their surprising frequency, offered an entirely new theoretical source for the origin of cells in the ovary that might produce neoplasms. Sampson's theory of transtubal implantation of endometrium is still receiving strong opposition. Halban (23), supported later by Mestitz (40), has proposed a theory of origin dependent upon a supposed transportation of endometrial material by way of the lymphatics to the ovary and other points at which endometrial implants were found. This has not, however, received the approval that has been accorded the serosal metaplasia theory, frequently suggested in the early studies of R. Meyer (42, 43) and of de Josselin de Jong (26), elaborated by Lauche (33) in 1922, and more recently discussed by Meyer (44), Robinson (62), Novak (53), Semb (70), and others, by which it is believed that various areas of the peritoneum have retained the ability under certain circumstances to form structures similar to the muellerian epithelium of the uterine mucosa. Whatever the origin of these structures, the fact remains that endometrial tissue is of far greater frequency in the ovary than had formerly been supposed and may surely be a fertile source of tumors.

In 1924 and 1925 Sampson (65, 66) developed his theory of cancer taking its origin from endometrial implants, and he referred to this particular type as "endometrial carcinoma" of the ovary. That the commonest form of carcinoma of the ovary closely resembles carcinoma arising in the uterine fundus morphologically, is obvious, but whether this is because the carcinoma arises from actually transplanted uterine mucosal tissue or from the surface epithelium of the ovary which is genetically related to the uterine mucosa through their common ancestor, the cœlomic endothelium, or finally whether in certain instances the ovarian surface epithelium passes by metaplasia through an endometrial stage before becoming carcinoma, is undetermined. No one, as far as we can discover, has been able to separate an "endometrial carcinoma" morphologically from what we might call the "germinal epithelium carcinoma" of the ovary, and though we had this in mind to do, if possible, while reviewing the present series, we

were unable to find even the smallest indication of a practical or theoretical structural ground for such a division.

The classification which we have used, therefore, follows closely that of Robert Meyer (41) and Pfannenstiel (56) in that it separates rather definitely the serous from the pseudomucinous tumors. This we felt is of particular value because of the possible origin of the serous tumors from endometrial growth in the ovary. The classification is as follows:

1. *Serous epithelial tumors.* These tumors, as we have stated, may originate from the germinal epithelium or from the heterotopic endometrial tissue. They form in all about one-third of the ovarian tumors, of which approximately one-half show papillary growths and one-half of these carcinomatous changes (Stuebler and Brandess).

2. *Pseudomucinous tumors.* These tumors may perhaps be similar in ultimate origin to the serous tumors, but they offer certain differences in their etiology and pathology to justify a continuation of their separation. The frequency of pseudomucinous tumors is variously reckoned from 30.6 per cent (Stuebler and Brandess) to 53.6 per cent (Lippert) and even two-thirds (Pfannenstiel) of all ovarian new-growths, but of these only 6.7 per cent are said to be malignant and only 2.07 per cent of the others to produce pseudomyxoma peritonei (Stuebler and Brandess).

3. *Teratomatous tumors.* These include: the dermoids which make up about 10 per cent of all ovarian tumors and of which only 3 per cent are said to be malignant (Lippert, Kroemer); probably the embryonal solid tumors found predominantly in young girls; struma ovarii; possibly also all of the pseudomucinous tumors and perhaps a good many other rare types the peculiar structure of which is due to the domination of the picture by one constituent of the teratoma.

4. *Sarcomata.* These tumors are probably extremely rare. Many of those neoplasms which formerly were diagnosed sarcoma, are now considered a type of round cell carcinoma. The frequency of these neoplasms has accordingly been variously estimated to form from about one to more than 5 per cent of all ovarian tumors (Lippert, 2.5 per cent; Pfannenstiel, 5.38 per cent; Stuebler and Brandess, 3.2 per cent; Schroeder, 1.6 per cent). In the present series the relation of sarcoma to carcinoma was 2 to 86.

5. *Metastatic tumors.* The relative frequency of secondary growths of the ovary as reported by different authors has varied greatly and seems to depend chiefly upon the source of the material examined and to some extent upon the author's bias in respect to the doubtful cases. Frankl's work, which can hardly be surpassed in its detail and which is based upon a study of operative material, showed 21.5 per cent of the ovarian growths to be metastatic while Ley in a series of 324 postmortem examinations performed for cancer found the ovaries involved in 60, of which 58.3 per cent were metastatic.

The secondary tumors may be grouped as follows:

a. Tumors primary elsewhere in the genital tract. Yet when a growth is found in the ovary coincident with a carcinoma of the endometrium or endosalpinx, there is often a particular difficulty in determining the actual primary site.

b. Krukenberg tumors of a specific histology and as a rule primary in some part of the gastro-intestinal tract.

c. A considerable number of glandular, medullary and diffuse carcinomata. This is not a well recognized group because of the general concentration of interest upon the Krukenberg tumor as the typical form of metastatic ovarian cancer, although Frankl has emphasized the frequent absence of the characteristic mucous cells in secondary growths and Stuebler and Brandess found the Krukenberg pathology in only 7 of 27 ovarian tumors that had had their primary focus in the gall bladder or stomach.

6. *Rare tumors of somewhat dubious status:*

a. *Luteomata.* This group of tumors has recently been reviewed by Wolfe in this country, and by Glyn in England, and there seems to be good evidence that such types of tumors occur, although they must be extremely rare.

b. *Hypernephromata.* This type of tumor has recently been carefully studied and discussed and probably eliminated as a form of ovarian tumor by Ernest Glyn.

c. *Chorio-epithelioma.* A type originally discussed by Pick (57) in 1904 which has been cropping up in the form of rare case reports ever since.

d. *Alveolar carcinomata of hermaphrodites.* A very interesting type, upon which there is a fairly extensive literature. Recent articles have been written by Meyer (45, 46) and Neumann (48).

e. *Granulosa cell tumors.* These are rare tumors, including a relatively benign variety known as the oophoroma folliculare (Brenner) and a malignant type, the folliculoid carcinoma (v. Kahlden). The tumors, though infrequent, appear to form a definite morphological group, although their relation to either ovum or follicle is much in doubt.

f. *Endotheliomata.* This is a much debated tumor about which Ewing sums up by stating that "critical research justifies the current skepticism." Aschoff likewise appears dubious about the existence of this tumor, while Borst on the other hand goes so far as to distinguish a hæmangio-endothelioma and a lymphangio-endothelioma. There were no cases in the present series that appeared to require or even suggest the diagnosis.

The classical division into solid and cystic, papillary and glandular tumors, we have entirely subordinated to the classification according to the finer cellular morphology,

because we feel that these variations in topographical arrangement have a relatively minor significance, often depending only on the point in the ovary of the origin of the tumor or the place in the tumor from which microscopic preparations were made. True solid tumors are extremely rare and seem as a rule to be of teratomatous or sarcomatous nature, but sections that appear to have been cut from solid tumors are fairly frequent either because the section is made in a region of diffuse infiltration from an otherwise papillary tumor (Fig. 12), or because from compression a papillary tumor, except in particular regions, may appear to be solid.

Glandular and papillary tumors are, as a rule, manifestations of a similar cellular process, the variations in form being due to the physical condition to which the surrounding tissue subjects them, and to some extent perhaps to cell function. Papillæ, are in fact, formed by two different methods: (1) by the simple sprouting of epithelium which carries a little connective tissue and blood supply with it (see Figs 3, 6); or (2) by the formation of multiple glands which dilate until the partitions rupture, the broken ends thus forming the projecting papillæ (for example see Fig. 13).

The former process produces the multiple branching papillæ of the serous cysts, the latter the peculiar interlacing structure of the pseudomucinous cysts. That both processes are operative to some extent in both types seems to be obvious from a study of the sections, although Meyer (41) in his contribution states that the mucinous cysts are only pseudopapillary. In many tumors one finds glandular or tiny cystic spaces which are filled with intraglandular papillæ, and the problem of classification on this basis becomes a still more difficult one. It should be mentioned also that a finding of a glandular carcinoma of the ovary, next to the typical Krunkenberg tissue, should awaken more suspicion of the tumor being secondary to a growth outside of the ovary than should any other histological finding. This should be particularly the case if nowhere can any attempt at papillary formation be found within the glands.

ANALYSIS OF PRESENT SERIES

The following classification was made of the 121 cases in which microscopic sections were still available for study and which had originally been diagnosed as papillary cystadenoma, primary carcinoma, and sarcoma. The first two varieties described below may perhaps not rightly belong in this series, but are included to indicate the errors that may arise when papillary cysts are reported without due consideration of the exact meaning of the terms employed.

Benign Papillary Tumors

1. *Cysts that are of tubal origin* (4 cases, Fig. 1). In three of these cases the diagnosis of cyst was first made by the pathologist, the surgeon having been under the impression that he was operating upon a case of chronic salpingitis. Microscopic sections, however, showed cystic spaces, with small, clublike, papillæ growing into them, with epithelium closely resembling that of the fallopian tubes and with a connective tissue, as a rule, of a hyaline character, but in places resembling the typical ovarian stroma. It is probable that these are not true ovarian cysts, but are either small areas of hydrosalpinx with regenerating epithelium adherent to the ovary, or are tubo-ovarian cysts formed by the adhesion and rupture of a hydrosalpinx into a follicular cyst and a subsequent proliferation of the tubal epithelium to line the ovarian component as well.

2. *Papillary fibro-adenoma* (9 cases, Fig. 2). This term has been employed to describe a very early type of growth that appears grossly as warty or very small papillary or cauliflower-like projections. These growths, in our series, occurred in cysts varying from small unilocular tumors of 3 centimeters in diameter, to larger cysts of 20 centimeters and were found singly, limited to one loculus of a multilocular tumor, or in some cases scattered diffusely over the whole lining of a large cyst, giving it a granular or sanded appearance. The fluid content is as a rule clear. The tumors are nearly always unilateral but the opposite ovary is often cystic (55 per cent). Microscopically, the tumors have the form of large, blunt, or bulbous projections consisting chiefly of stroma. The connective tissue is occasionally hyaline but the œdema that tends to appear in the tips of the papillæ gives them a myxomatous appearance. The epithelium, as a rule, is flat, especially in the dilated papillæ. In other regions there may be multiple layers of very fine cells and occasionally little papillary projections, indicating an approach to the group of true papillary cystadenomata. Finally, the papillæ may contain a few glands and muscle fibers indicating an adenomyomatous origin. These tumors have apparently no tendency toward malignancy, although one of our patients developed another tumor 8 years later, probably in the opposite

ovary, though this has not been proved by operation. In these cases the growths are probably to be considered as precursors of the papillary cystadenomata and are similar in their pathological status to the intracanalicular fibro-adenomata of the breast

3. *Papillary cystadenomata* (21 cases). These tumors are distinguished from the preceding group of the fibro-adenomata by their essentially epithelial character, and from the succeeding group of carcinomata by the perfect regularity of the cellular arrangement and by the uniform and fully differentiated character of the cells themselves which may, however, show wide variations among different tumors due to differences in the stage or type of their secretory functions and to the degree of rapidity of their proliferation (hyperplasia).

a. *Serous cysts* (16 cases). These tumors varied from a few centimeters to 25 centimeters in diameter, but the majority measured about 15 centimeters. The greater number were multilocular but the fluid content varied from clear through thick and brown to purulent. The projections were sometimes warty as in the previous variety, but frequently formed large papillary masses, though it must be stated that the most active proliferation was sometimes found in the smallest papillæ. Sometimes, only one small loculus of a very large cyst was involved; in others a large cyst might be nearly filled with a papillary growth springing from a single tiny pedicle, while other cysts possessed walls which were uniformly shaggy with papillæ. Microscopically, the papillæ were multiple, branching structures with little interlacing and were covered with an invariably ciliated epithelium. Two degrees of activity could rather easily be distinguished; one a relatively inactive (Fig. 3), the other an extremely hyperplastic variety (Fig. 4, 5) that gave evidence of approaching a carcinomatous condition. In the former, the connective tissue was relatively abundant, the papillæ broad and simple in structure. The cells varied little in size, were often dilated a little from contained secretion and contained a medium sized oval nucleus, and only an occasional acidophilic nucleolus. *The hyperplastic type*, on the other hand, showed multiple, fine branching papillæ with many fine secondary offshoots, and an epithelium made up of tall columnar cells, very closely packed together, with little or no cytoplasm, and slender, tall, dark nuclei with many striking nucleoli. The identification of these varieties is important. Of the inactive type, of which there were 8 cases, only one was bilateral (another had had a previous unilateral oophorectomy), and there were no cases with implants on the peritoneum. One patient died of postoperative shock, 3 are alive and well over 5 years, and the others are known to be well for a shorter time. Of the hyperplastic variety, 3 were bilateral, and each of these had implants scattered diffusely over the peritoneum or in the intestine or omentum, one other had ascites and external papillæ on the surface of the cyst, while a fifth had external papillæ alone. In spite of this, 2 of the patients have lived 14 years, another 6, one other 4, and the 3 others are alive and well less than that time.

It is this hyperplastic type of papillary cyst, which we believe is the one involved in the spectacular reports of regression of carcinomata of the ovary following incomplete operation. It should be noted that of the 3 patients in whom the abdomen was closed with the operation undoubtedly incomplete (and who have now lived 14 years, 6 years, and 4 years, respectively), each had not reached the menopause. If we regard this type of papillary cyst with implants upon the peritoneum as a hyperplasia of a peritoneal endometriosis or of a tissue with similar functional status, the explanation of the regression following castration becomes more simple. In our entire series we have no case of a true cancer showing any sign of spontaneous regression, although some pathologists might classify our hyperplastic papillary cysts as carcinoma.

b. *Pseudomucinous tumors* (6 cases). Grossly, these are as a rule, very large tumors, although in our series the smallest was 4 centimeters in diameter, and the largest 40 centimeters. They were invariably unilateral, and usually multilocular though one chamber usually predominated. Although in the serous tumors the fluid was often thick and viscous, it is invariably so in the pseudomucinous tumors and is as a rule described as jelly-like. The papillæ are small and insignificant, and the papillary nature may often not be discovered until the pathological examination. Microscopically (Fig. 13), the papillæ show an interlacing structure indicating their glandular origin. The epithelium has a palisade-like appearance with occasional little tuftlike projections without connective tissue participation in their growth. The cells are filled with clear mucus throughout their distal two-thirds, while the nuclei lie flattened at the bases. Cilia are never found. Of the 6 cases in this group, 2 are alive and well 5 years, 2 for a shorter time, and 2 have been lost. There is, of course, no reason to expect late developments in this type beyond the remote danger of the formation of a pseudomyxoma peritonei.

The summary of the 21 cases of papillary cystadenoma of mucous and serous types is therefore as follows:

	Cases
Incomplete removal of growths	3
Ascites	3
Operative deaths	1
Deaths from intercurrent disease	0
Recurrences	0
Lost	2
Alive over 5 years	8
Alive over 3 years	2
Alive under 3 years	8

MALIGNANT TUMORS

The 88 remaining tumors were malignant, all being carcinomata except 2 cases which were sarcomata. In classifying these tumors, we have attempted to follow the customary divi-

Fig. 1. Papillæ of possible tubal origin, which were adjacent to the ovarian tissue simulated a cystadenoma.

Fig. 2. Papillary fibro-adenoma. Low power. The epithelium is composed of very small cells, the stroma of dense, but in places of œdematous fibrous tissue.

sion into degrees of malignancy. This has been possible in the more common mucous and serous tumors, but we have been obliged to add a miscellaneous group unclassified in regard to degree of malignancy. This group contains those tumors in which there is a question as regards the primary point of origin or which are too rare to justify any subdivisions.

Probably because in ovarian carcinoma, we are dealing with adenoid and not epidermoid types, we found Greenough's (21) method of classification somewhat more useful than Broders' (6, 7), although the two systems are in reality mutually complementary. The three chief points upon which the estimation of malignancy depends, are as follows:

1. Loss of adult structural form, which Greenough describes as the loss of the adenomatous arrangement of tumor cells around an open space and which can be translated into the pathology of our papillary tumors as the development of a multiple or irregular arrangement of the epithelial cells in relation to the connective tissue stem of the papilla.

2. The loss of evidence of adult functional capacity, this capacity being evidenced in the ovarian neoplasms by the dilatation of the cells with mucous secretion in the pseudomucinous tumors and by the presence of clear areas in the cytoplasm and the presence of cilia in the serous tumors.

3. Nuclear changes, by which is meant hyperchromatism, irregular and frequent mitosis, and variations in form and size.

Greenough divided the tumors into high, medium, and low malignancy upon a more or less general appreciation of the status of the tumors on the basis of these three factors, while Broders based his classification upon the percentage of undifferentiated elements found. The latter method seemed entirely inapplicable in these ovarian tumors because all of the cells in any given section appeared to have

Fig. 3. Low power photomicrograph of a papillary serous cystadenoma of the inactive type. The epithelium is more prominent than it is in the fibro-adenoma type.

Fig. 4. Papillary serous cystadenoma. Hyperplastic type. Low power. The epithelium is composed of very high columnar cells. This growth had perforated the cyst and was growing on the peritoneal surface. Patient alive and well 3 years.

advanced to approximately the same degree of malignancy and to be entirely unclassifiable on the basis of a mathematically stated percentage of undifferentiated cells.

One particular point stressed by Broders (7) as a sign of malignancy, was the relative frequency of the "one-eyed cell" by which term he designated cells with large, dark-staining nucleoli. In the ovarian tumors, a large, pink-staining nucleolus had impressed us as a striking feature even before our discovery of Broders' discussion of it. This structure seemed to us, however, to have to do with rapidity of proliferation rather than with the degree of undifferentiation, because it was found in many of the rapidly growing benign papillary cysts as well as in the more malignant tumors but was again a less striking finding in the extremely undifferentiated tumors of Grade III, that we have some reason to believe are more slow-growing than Grade II.

The simplest possible system of classification of adenomatous and papillomatous tumors seems to be as follows:

Grade I. Tumors in which the adult structural form is *almost universally* maintained and in which malignancy is indicated only by moderate nuclear changes or by occasional small areas of loss in the adult arrangement of cells in relation to lumen or basement membrane. This is the adenoma malignum type.

Grade II. Tumors which are strikingly malignant in their loss of adult structural form, but which *invariably* in some places show *some* glandular arrangement or its equivalent papillary form.

Grade III. Tumors in which glandular or other adult forms *never* occur. Diffuse carcinoma.

This classification is based primarily upon the first criterion of malignancy, namely upon polarity. Since the glandular arrangement is

Fig. 5. Papillary serous cystadenoma. Hyperplastic type. Low power. Multiple fine branching papillæ and high columnar epithelium. Multiple peritoneal implants and ascites. Patient alive and well after 14 years.

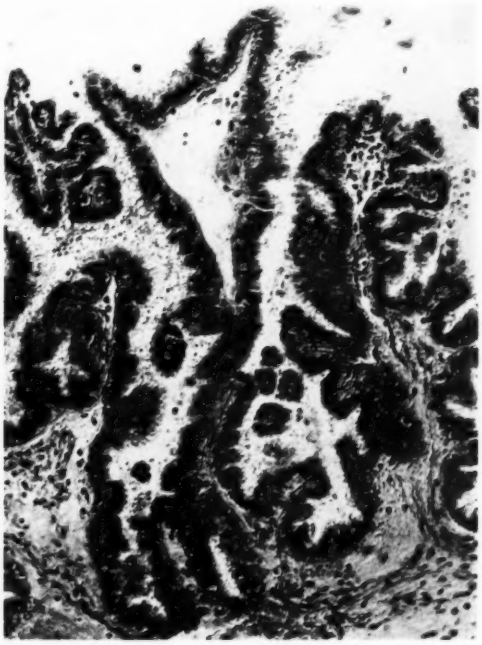

Fig. 6. Papillary serous cystadenocarcinoma. Grade I. Low power. Malignancy so early as to be almost in doubt. Recent case doing well.

also an index of cell function, it was logical that the disappearance of intracellular evidence of adult secretory function should be found to run parallel with the disappearance of the secreting forms of cellular arrangement. The third criterion, namely nuclear irregularity, which we feel should perhaps not be considered as a sign of loss of differentiation but of some entirely new factor connected with rapidity of proliferation, did not parallel these losses of adult form and function but was more marked in our Group II than in Group III.

GRADE I.—CARCINOMA—TWENTY-SIX CASES

Subgroup 1. Serous papillary carcinoma (12 cases, Figs. 6 and 7). The cysts in these cases were slightly smaller than those in the previous benign variety, averaging about 10 centimeters in diameter. In 5 cases the cysts were bilateral, in 3 unilateral, in 3 previous operations had been done and the opposite ovary removed, and in 1 the condition of the other ovary was undetermined. The papillary masses, as a rule, nearly filled the cyst, and in 2 cases had the form of external papillomata. Four patients showed peritoneal metastasis. Microscopically, there were two somewhat distinct types. One showed peritoneal papillæ lined with rather regular single or double tiers of cells with oval, slightly vesicular nuclei. The other, in which fell the external papillomata and two small intracystic growths, showed cauliflower-like clumps of papillæ filled with small glandular spaces and lined with a single layer of epithelial cells with tiny, round, dark nuclei. In most of these tumors ciliated cells could be found with sufficient search and the oil immersion lens. In this group, 3 patients died from operation; 3 from a recurrence of the disease 2½, 3, and 3½ years after operation, respectively; 1 patient is alive and well after 8 years; 1 for 4 years; 3 are alive and well for a period less than 3 years; and 1 is lost. The patient alive for 4 years had a resection of an omental metastasis as well as a bilateral oophorectomy.

Subgroup 2. Glandular carcinoma (*6 cases*, Fig. 8). These tumors are of somewhat doubtful origin, but may be merely a morphological variety of the serous cysts. Five of these tumors were unilateral and consisted of definite cysts averaging 15 centimeters in diameter. Of these, 4 showed peritoneal implants. The papillæ consisted of polypoid or

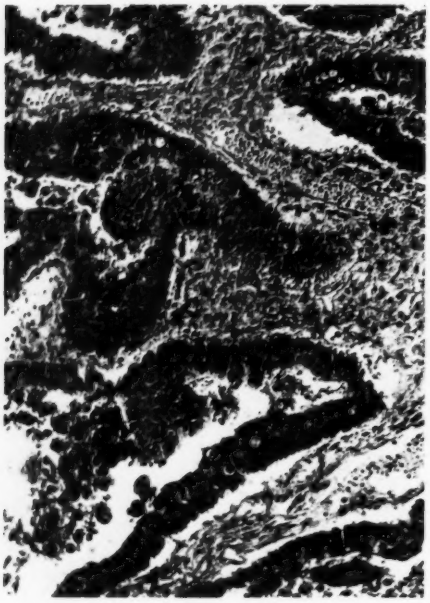

Fig. 7. Papillary serous cystadenocarcinoma. Grade I. Low power. Definitely more malignant than Figure 6. Patient died of recurrence 3 years after operation.

Fig. 8. Glandular and papillary cystadenocarcinoma. Grade I. High power. Patient died of recurrence one and a half years after operation.

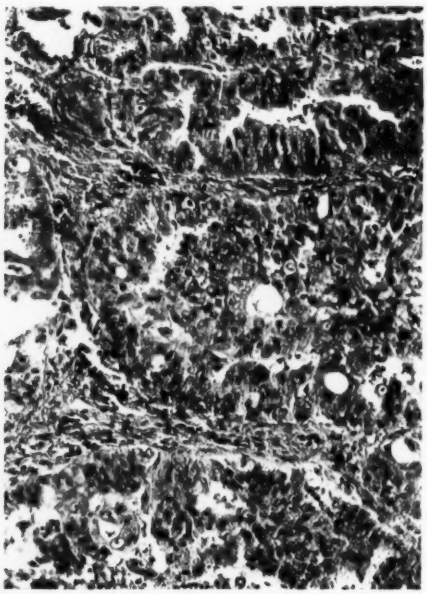

Fig. 9A.

Fig. 9B.

Fig. 9A. Papillary serous cystadenocarcinoma. Grade II. Low power. Very large nuclei with hyperchromatism and prominent nucleoli. Rapidly fatal type.

Fig. 9B. Papillary serous cystadenocarcinoma. Grade II. High power. Very large nuclei with hyperchromatism and prominent nucleoli. Rapidly fatal type.

Fig. 10A.

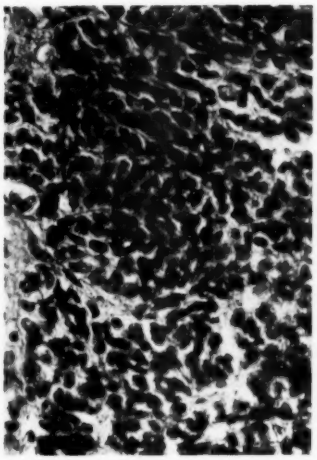

Fig. 10B.

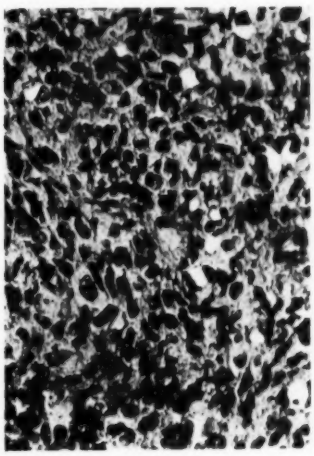

Fig. 11.

Fig. 10A. Papillary cystadenocarcinoma. Grade III. Low power. Small, comparatively uniform cells. Faint attempts at papillary structure in places. Patient died in 9 months.

Fig. 10B. Papillary cystadenocarcinoma. Grade III. High power. Small, comparatively uniform cells. Faint attempts at papillary structure in places. Patient died in 9 months.

Fig. 11. Solid carcinoma. Grade III. High power. Small, relatively uniform cells. No attempts at glandular or papillary formation. Patient died of recurrence in 6 months.

granular masses. The tumors were usually multilocular, the fluid content being as a rule too cloudy with débris to permit identification. Microscopically, the tumor consisted of immense hypertrophic glands and papillæ covered with thick bands of a similar hypertrophic epithelium. This epithelium was composed of large cylindrical or oval nuclei closely packed in together, uniform in size and shape, but showing many mitoses and intensely stained nucleoli. Four of these cases are dead of the disease and one lost, the one lost being the only one without peritoneal implantations.

The sixth case occurred in a very young woman and consisted of tiny, warty cystic growths in both ovaries, these tumors showing on section a small glandular carcinoma with large polygonal cells and round nuclei quite different in structure from the polypoid glandular carcinoma noted above. The patient was treated by removal of one ovary and partial resection of the other, and she was alive and well 2 years after the operation when she died of an intercurrent infection.

Subgroup 3. Mucous carcinoma (*5 cases*, Fig. 14). These were all large cysts, all unilateral (except one case in which the patient had had a previous operation), all filled with a glairy or gelatinous or mucoid substance, but now showing in contrast to the pseudomucinous cystadenomata definite cauliflower and fungating masses projecting into the cysts. Only one, that which had been previously operated upon, showed peritoneal implantation. Microscopically, these tumors present the same delicate, feathery, interlacing forms as the benign mucous cysts, but the cells were larger and the nuclei more vesicular, and small solid clumps with evidence of loss in polarity occurred in places. In some tumors the secretion of mucous had been so tremendous as to

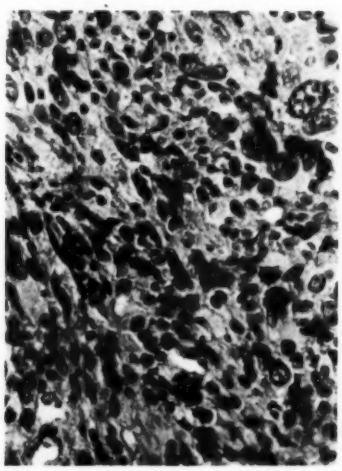

Fig. 12. Invading cells of a papillary cystadenocarcinoma. High power. Illustrating a possible error in the diagnosis of solid tumors.

Fig. 13. Papillary pseudomucinous cystadenoma. Low power. Illustrating the interlacing form of these tumors and their origin from dilated glands.

cause some disintegration of the cells. In the mucous group 2 patients died of the disease, 2 were lost, and 1 is alive and well 1 year after the operation.

Subgroup 4. Pseudomyxoma peritonei (3 cases, Fig. 17). These cases really belong to the group of early pseudomucinous carcinoma, but are separated here because they form a well recognized clinical entity. Each of our cases had had a previous operation for ovarian cyst, varying from 1 to 11 years previously. In each, the peritoneal cavity was filled with mucous masses and tiny mucoid cysts. Microscopically, the tissue showed immense areas of homogeneous mucoid material, with here and there small cyst-like bodies. Very frequently, these cystic spaces showed proliferation of a mucoid epithelium at one end and an atrophy with a streaming out of mucus into the tissues at the other end. The three patients were inoperable and 2 were dead within 3 months. In spite of these three bad results, it appears that pseudomyxoma peritonei may at times be produced by the proliferation of benign mucous cells in the peritoneum (Biggs 2) and occasional regression after partial operation has been noted (Pfannenstiel, 56).

The end-results in the 26 cases of Grade I carcinomata were therefore as follows:

Fig. 14. Pseudomucinous cystadenocarcinoma. Grade I. Heaping up of cells into irregular clusters. Great production of mucus. Patient died in 13 months.

	Cases
Incomplete operation	7
Operative deaths	3
Died from intercurrent disease	1
Deaths or recurrence	11
Alive and well under 3 years	5
Alive and well 3 to 5 years	1
Alive and well over 5 years	1
Lost	4

Average time of death of those that died from the disease—21 months.

GRADE II.—CARCINOMA—THIRTY CASES

This group includes the cases in which the adult structural forms, that is to say, the glandular and its equivalent papillary structures, are badly distorted, but in which at least traces of these forms are definitely present. Some evidence of secretory activity in the cell bodies is also still seen, especially in the mucous types. The nuclei are very irregular in form and shape, but as a rule very large and vesicular, and mitosis, often atypical in appearance, is frequent. When papillary tumors of this type infiltrate, they usually tend to form glands and small clumps, while in Grade III the invasion is by large sheets of diffusely growing cells.

Subgroup 1. Serous papillary carcinoma (16 cases, Fig. 9). These tumors were semi-solid and cystic masses which were filled with friable, papillary material. In our cases the sizes varied from 10 to 20

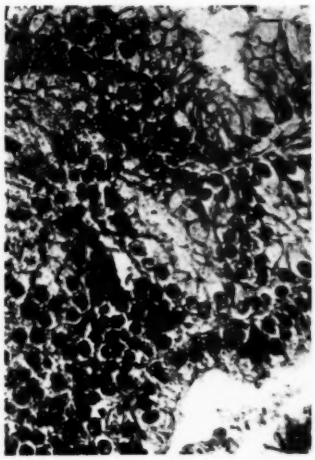

Fig. 15.

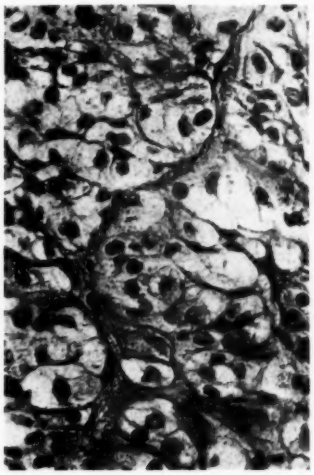

Fig. 16.

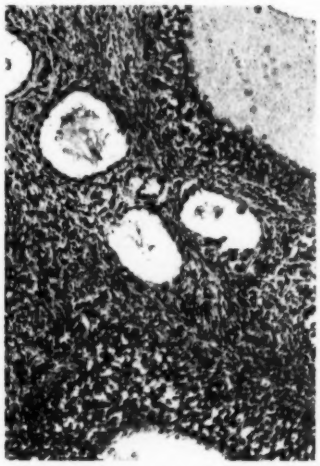

Fig. 18.

Fig. 15. Pseudomucinous cystadenocarcinoma. Grade II. High power. The tendency to form large solid masses of cells is shown. Patient alive with recurrence after 3 years.

Fig. 16. Pseudomucinous cystadenocarcinoma. Grade II. High power. The papillary structure faintly suggested but mucus secretion in cells indicates a partial differentiation. Patient died 2 months after operation.

Fig. 18. Folliculoid cancer. Low power. The gland-like spaces are surrounded with multilayered band of cells that can also be seen invading the stroma. Patient alive and well 2½ years after operation.

centimeters in diameter. In 13 patients the cysts were bilateral, in 2 unilateral, and in 1 the opposite ovary had previously been removed. Of the 16 cases 15 had either ascites or implants, although in two of these the implants were restricted to the uterus or tubes. Microscopically, the tissue consisted of masses of cells in multiple tiers upon the papillæ with only here and there a sign of orientation as indicated by the perpendicular row of basement cells or rarely as a segment of a papilla covered by a single, regularly arranged row of cells. The cells themselves were large polygonal structures with plenty of cytoplasm, rather definite cell boundaries with large vesicular nuclei, granular peripheral chromatin and a large, central, pink-staining nucleolus. One patient died from operation, 12 died of the disease on an average of 5½ months after the operation, 1 had a recurrence, and 2 are so far free from recurrence but have not yet reached the two year interval.

Subgroup 2. Glandular carcinoma (6 cases). There is a definite possibility that some of these tumors, described below, especially among the more advanced cases with multiple implants, may be primary elsewhere than in the ovary. The tumors were about the same size as in the papillary cysts, were bilateral in 5 cases and unilateral in one. The five bilateral cases all showed multiple peritoneal implants. Microscopically, the cells were for the most part similar in morphology to those of the papillary groups but were arranged in the form of glands with

Fig. 17. Pseudomyxoma peritonei. Grade I. Mucous carcinoma. Low power. Tiny cyst-like spaces lined with mucus-producing epithelium in a connective tissue filled with mucous areas. Case quite inoperable.

small intraglandular papillæ. These appear to be quite similar in origin to the papillary tumors but in 2 cases the glands were composed of smaller cells and were much evener in contour which suggested their being of different origin. These 6 patients are all dead.

Subgroup 3. Mucous carcinoma (5 cases, Figs. 15, 16). At the stage of differentiation reached in Grade II, the mucous tumors have become rather difficult to recognize, and mistakes may have been made in their classification in this article. With special stains (muci-carmine), identification should be possible (Ley, 35; H. O. Neumann, 51), and is a procedure which should be carried out for the proper diagnosis of these tumors. In 3 of these patients the cysts were unilateral and in 2 bilateral. In 3 there were secondary peritoneal growths. Microscopically, the cells were large, with pale or non-staining cytoplasm, definite cell boundaries, large, round nuclei occasionally slightly compressed. The arrangement was alveolar, glandular, or papillary. Of these five patients, 2 are dead from the disease, 1 is lost, 1 is alive with recurrence at 3 years, and 1 is alive and well at 3 years.

Subgroup 4. Colloid carcinoma (3 cases). It is possible that this type should be included under the previous mucous group and also that at least one of the three may be metastatic. In this particular case the colon as well as the ovary was involved but the patient was a girl of 21 who had never menstruated. In the other 2 cases there were large cysts, each over 30 centimeters in diameter with only small areas of carcinoma in their walls. Only 1 of the 3 cases was bilateral but 2 showed growths on the peritoneum. The pathology was of two different types. In one, the case of the 21 year old girl, there was a typical colloid carcinoma of the intestinal type with large acellular fields into which irregular projections of possibly regenerating epithelial cells were growing. In the other type there were multiple glands filled with mucus with the lining cells desquamating into them. The desquamating cells often showed a signet ring form and one case was associated with a pseudomucinous cyst. All 3 patients are dead, 1 from the operation.

Of the 30 cases the end-results in Group II are:

	Cases
Incomplete operation	19
Operative deaths	4
Died intercurrent	0
Death or recurrence of disease	22
Lost	1
Alive and well 5 years	0
Alive and well 3 years	1
Alive and well under 3 years	2
Average age death in months	5½

GRADE III.—CARCINOMA

In this group there is no vestige of adult cellular arrangement and signs of epithelial function have disappeared. In spite of this, nuclear irregularity has not increased at a rate proportional with the loss of differentiation and consequently, though this is the least differentiated group it appears to be not necessarily the most malignant. In a few of these tumors there is a marked hyperchromatism and other nuclear signs of anaplasia, but in the majority, the cells are small, uniform in size, closely packed together with almost absent cytoplasm, no cell borders, and tiny oval nuclei with little distinguishable intranuclear structure. On account of the complete absence of differentiation, histogenetic speculation on a morphological ground is futile, and so the classification on the basis of mucous and serous types must be discontinued. Possibly on account of the suppression of the secretory function, many of these tumors are entirely solid or at least only partly cystic.

Subgroup 1. Papillary carcinoma (12 cases, Fig. 10). These are cystic and solid tumors varying from 5 to 20 centimeters in diameter. In 6 the cysts were bilateral, in 2 previous ovarian operations had been done, in 2 the exact distribution was undeterminable, and in 2 the cysts were unilateral. Nine showed peritoneal implants, in 1 the matter of implants was questionable, and 2 were free from implants. Microscopically, the section consists of immense, vaguely defined papillary masses with the cells adherent to the stem in the form of immense grapelike clusters. In many regions the papillary structure is lost and only irregular sheets of cells remain. The cells show little structure except the small, round, or oval relatively uniformly staining nuclei. Of the 12 cases 1 patient died immediately after the operation, 5 more died on an average of 14 months after the operation, 2 are alive with recurrence, 2 are lost, 1 is alive and well under 3 years, and 1 is alive and well for 4 years. The latter was one of the unilateral tumor cases.

Subgroup 2. Solid carcinoma without glandular or papillary structure (4 cases, Fig. 11). In this group probably belong the embryonal tumors found predominantly in young women. One of our patients was 16 years of age. A diagnosis of sarcoma was considered in 3 of the 4 cases. In 3 cases and perhaps 4 the cysts were unilateral. The tumors were relatively small, the largest 13 centimeters in diameter, and there were no cases with peritoneal implantations. Microscopically, the tumors consisted of round, diffusely growing cells of relatively uniform appearance and without remarkable mitosis or hyperchromatism. One patient is living and well 5 years, 1 is alive with recurrence at 13 months, 1 died at 22 months, and 1 at about 6 months. Pfannenstiel (56) finds solid tumors a trifle less liable to recurrence than the papillary variety.

A summary of the end-results which were found in the 16 cases included in Grade III shows the following:

	Cases
Incomplete operation	9
Operative deaths	1
Deaths or recurrence from disease	10
Lost	2
Alive and well 5 years	1
Alive and well 3 to 5 years	1
Alive and well under 3 years	1
Average time of death in months	13

On the whole, both pathologically and clinically, this group seems a little less malignant than the more differentiated but also more irregularly growing carcinomata of Group II.

MISCELLANEOUS

The miscellaneous group includes the following:

1. Adenomatous tumors of the ovary associated with tumors arising elsewhere in the genital tract: (a) carcinoma of fundus and ovary; (b) carcinoma of tube and ovary; (c) carcinoma of cervix and ovary.
2. Rare epithelial tumors: (a) folliculoid; (b) squamous carcinoma of dermoid; (c) carcinoma of cyst of Morgani.
3. Krunkenberg.
4. Sarcoma.

a. Carcinoma of fundus and ovary. Novak (54) has recently published a study of the combination of ovarian and uterine carcinoma which occurred in 7 of 147 cases of carcinoma of the fundus. In the present series, combined carcinoma of ovary and fundus occurred in 5 of 86 cases of carcinoma of the ovary. It was Novak's belief that coincident carcinoma of ovary and fundus was nearly always primary in the fundus and spread to the ovary through the lymphatics, which resulted in the growth appearing in the ovary as an invasion from the center outward. Sampson (65) believes in a transtubal implantation on the ovarian surface of a primary fundus carcinoma. The subject has a considerable German literature which has recently been discussed by Burckhard (8). Lymphatic spread should theoretically be simpler from the uterus to the ovary than the reverse, and the majority of writers seem to favor the fundus as the usual primary, although nearly all admit the possibility of either organ producing at times the original of the coincident tumors. The possibility of the spontaneous independent incidence of two tumors should not be entirely discarded. The argument in favor of the truth of this mode of origin may be arranged as follows:

1. Ovarian tumors have a predilection for early, if not simultaneous involvement of both sides, and this is especially true of the type that resembles uterine carcinoma. It may be argued that in bilateral ovarian growths, the tumors are primary in only one ovary, but the simultaneous formation of multiple papillomata over a large area of the inner surface of a cyst or in several separate loculi of the cyst can hardly be denied.
2. Ovarian carcinoma may arise from endometrial growths in the ovary, practically identical with the uterine mucosa, or if from the germinal epithelium from a genetically rather closely related structure.
3. Ovarian endometriomata are known to respond in a way similar to the uterine mucosa to the stimuli of menstruation, pregnancy, and menopause. If the unknown stimulus to the production of cancer can produce multiple growths simultaneously in two ovaries, it is distinctly a possibility that it may also produce similar growths in a third location of the similarly functioning tissue.

In our series of combined ovarian and fundus carcinoma, the ovarian tumor was bilateral in 3 cases and unilateral in 2 cases. Contrary to Novak's findings that most of the ovaries in these cases of combined tumors were smooth, relatively small, firm structures all of the ovarian tumors in this series were definite papillary cysts, no case being without a cyst at least 10 centimeters in diameter, and one was as large as 20 centimeters. The records on the distribution of the papillary growths in the fundus and in the cysts are unfortunately somewhat vague and the gross specimens were not available for a new study. All of the cysts were, however, multilocular, and the papillæ were internal and numerous. Apparently, in all the uteri, carcinoma was universal except in one case in which it was limited to one horn on the side opposite the involved ovary. Microscopically, the morphology followed rather closely the structure described under Grades I and II of the serous cysts already described. In one tumor the fundus slides are lacking. In one, the tumors are identical in appearance in ovary and endometrium and of the Grade I type. In the three remaining cases, the ovarian growth is definitely of a more malignant type than in the other. Of these 5 cases, 2 patients are dead, the others are well but still under the 3 year period.

b. *Carcinoma of tube and ovary (2 cases).* This combination offers a somewhat similar problem. Our 2 cases include only those in which there was an extensive involvement of the endosalpinx, and does not include those with merely serosal implants. In the more recent case of the two, there were large, bilateral, unruptured, papillary, ovarian cysts and both tubes were dilated to a diameter of 4 centimeters and uniformly filled with papillary material. The gross description of the other is a very old one and is not complete. Microscopically, the tissue is similar to that of the ovarian carcinoma of Grade II, except that the cells are perhaps somewhat smaller. One patient is dead, the other lost.

c. *Carcinoma of cervix and ovary (1 case).* This case developed a bilateral papillary cystadenoma of the ovary 3 years after radiation of the cervix for epidermoid carcinoma. In one loculus of the papillary cyst was found what appeared to be a metastasis of a squamous carcinoma. There are a few cases reported of development of ovarian tumors after radiation (Grosse, 22; Vogt, 76). This case died 1½ years after the operation for the cyst. Frankl (15) has reported 3 similar cases of papillary adenocarcinoma of ovary with squamous carcinoma of cervix.

2. *Rare epithelial tumors.* a. *Folliculoid carcinoma (1 case,* Fig. 18). This consisted of a multicystic and solid unilateral ovarian tumor in a girl of 22 years, whose menstruation had always been irregular but had entirely ceased 2 years before the operation. Microscopically, the tissue showed numerous round spaces surrounded by multiple layers of peculiar, small, round cells, and an ovarian stroma invaded diffusely by the same type of cells. Although these tumors are rather unusual, there is a very extensive list of case reports, mostly in German, of similar and supposedly allied types (Neumann, 49, 50; Blau, 3; Schiffmann, 69; Krompecher, 31; Robinson, 63). The present case is peculiar, in that the majority of the others have occurred in women who are past the menopause and are accompanied by a return of the menses rather than by their cessation. The case just described is alive and well nearly 3 years postoperative.

b. *Squamous carcinoma of dermoid cyst (2 cases).* In both of these cases, there were unilateral dermoid cysts with hair, and in each case there were peritoneal metastases. Microscopically, the malignant areas showed invading masses of large, undifferentiated cells, with only here and there evidence of their squamous origin. Both patients died within 3 months. Neuhauser (47) reported a collection of 35 such cases (26 operable) of which only 3 could be considered cured even over a short period.

c. *Carcinoma of a cyst of Morgagni (1 case).* This is a very old case and the reports are very meager. Grossly, the tumor consisted of a small, cauliflower growth into a cyst of Morgagni. Microscopically, the tissue consists of fibrous tissue with small clumps of large, round, malignant cells. The ultimate fate of this patient is unknown.

3. *Krukenberg tumors (2 cases).* The peculiar structure of these tumors has attracted an immense amount of attention since their original description in 1896. The subject has been widely discussed and reviewed in this country by Stone (73) and Major (38), in England by Shaw (71), and in Germany by Frankl (15), and by a host of others. Histologically, the tumor consists of a dense, almost sarcomatous fibrous tissue, invaded by mucus-producing epithelial cells that have often a signet ring form due to the dilatation of cells with mucus and the compression of the nucleus. This tumor can theoretically be produced by the reaction of the ovarian stroma to a malignant invasion of mucous epithelial cells from any source. The tumors are consequently considered to be, as a rule, secondary to a primary carcinoma of the intestinal tract or gall bladder, but the existence of primary ovarian Krukenberg tumors can be explained by the diffuse growth of mucus cells from an ovarian pseudomucinous carcinoma through ovarian stroma. Neumann (51) has, in fact, published in great detail the report of such a case. In spite of the fact that these two cases were originally classed as ovarian growths, both were almost certainly secondary, one patient having had a gall-bladder operation of unknown nature 2 years previously, and the other showing some gastric involvement at the time of the operation. In each case there were bilateral ovarian tumors, ascites, and multiple peritoneal growths. The histology was quite typical, although signet ring forms were difficult to find in one of the cases. In both of these cases it was not possible to operate and the patients promptly died.

4. *Sarcoma (2 cases).* One of these cases was a spindle-cell sarcoma in the wall of an immense ovarian cyst which was not recognized at the time of the operation, and recurred in the form of a similar sarcomatous cyst in the opposite ovary 1 year later. Although there was no evidence at the later laparotomy of extension beyond the ovary the patient died from this second operation. The other patient presented an immense, solid and cystic unilateral tumor with omental and uterine nodules. The histology showed round cells in places; in other regions, there were cells resembling smooth muscle fibers. This patient is alive nearly 4 years since the operation but she has had signs of a recurrence for at least 2 years.

Although of little significance since they represent such a mixed group, the end-results for the 16 cases of the miscellaneous tumors are as follows:

	Cases
Incomplete operation	8
Operative deaths	1
Died or recurred	9
Alive and well 5 years	0
Alive and well 3 years	0
Alive and well under 3 years	4
Lost	2

TABLE I.—COMPLETE SUMMARY OF RESULTS

	Number	Hysterectomy and Bilateral Oophorect.	Bilateral Oophorectomy	Unilateral Oophorectomy	Exploratory and Palliative	Died from Operation	Died from Recurrence	Alive with Recurrence	Died Intercurrent	Alive and well—5 years	Alive and well—3 years	Alive and well—6 months to 3 years	Lost	Cases with incomplete removal of growth
Papillary tubo-ovarian cysts	4	3	0	1	0	0	0	0	0	0	0	4	0	0
Papillary fibro-adenoma	9	4	0	5	0	0	0	0	1	2	0	3	3	0
Papillary cystadenoma	21	14	0	7	0	1	0	0	0	8	2	8	2	3
Pap. cystadenoma—unreviewed cases	11	8	0	3	0	0	1	0	0	4	2	2	2	2
Total papillary cystad.	45	29	0	16	0	1	1	0	1	14	4	17	7	5
Carcinoma, Grade I	26	13	2	5	6	3	10	1	1	1	1	5	4	7
Carcinoma, Grade II	30	13	4	5	8	4	17	5	0	0	1	2	1	19
Carcinoma, Grade III	16	10	0	0	6	1	7	3	0	1	1	1	2	9
Carcinoma, miscellaneous	14	7	1	3	3	0	6	2	0	0	0	4	2	6
Carcinoma—unreviewed cases	4	3	0	0	1	2	0	0	0	0	0	0	2	1
Total carcinoma	90	46	7	13	24	10	40	11	1	2	3	12	11	42
Sarcoma	2	1	0	1	0	1	0	1	0	0	0	0	0	1
Sarcoma—unreviewed cases	2	2	0	0	0	0	1	0	0	0	0	0	1	2
Total sarcoma	4	3	0	1	0	1	1	1	0	0	0	0	1	3
Final total	139	78	7	30	24	12	42	12	2	16	7	29	19	50

END-RESULTS OF TREATMENT

Primary mortality. In the entire series of 139 cases, there was a primary operative mortality of 8.6 per cent, which can be divided into a rate of 2.2 per cent for the relatively benign tumors (fibro-adenoma and papillary cystadenoma), and 11.8 per cent for the definitely malignant cases. The latter figure is not high considering the desperate character of many of the operations. Other writers have published their primary mortality statistics as follows: Mayfield (39), 5 per cent; Norris and Vogt (52), 5.2 per cent; Stuebler and Brandess (75), 11.4 per cent; Schaefer (67), 17.1 per cent; Byron and Berkoff (9), 20.3 per cent. These figures are, of course, closely related to the surgeon's conception of his duty toward the almost hopeless case in which the advisability of attempting an extensive operation is debatable.

Late results. The pathologically reviewed group in this series of malignant and semimalignant tumors (the latter exclusive of papillary fibro-adenomata and cysts of possibly tubal origin) comprises 109 cases of which 62 are known to be dead from the operation or the disease or to have had a recurrence; one has died from an intercurrent infection; 11 are lost; 10 have lived over 5 years (9.2 per cent); 5 more over 3 years (4.6 per cent); and 20 (18.3 per cent) are alive and well from 6 months to 3 years. Thus in all, 32 per cent may be included in the group with a fair prognosis. Of the cases of true carcinoma (including 10 cases possibly secondary), there were 86 cases, of which 59 are dead or have had a recurrence of the cancer, one has died from intercurrent infection, 9 are lost, 2 cases have remained well 5 years, 3 for 3 years, and 12 for a shorter period. Thus of the malignant group, 5.8 per cent have passed 3 years and 13.9 per cent more are free from recurrence at least 6 months after operation, so that in all 19.7 per cent have a fair prognosis although only 2 out of 86 have actually passed the 5-year mark.

Stated in different terms—of the 71 cases of papillary cystadenoma and carcinoma operated upon over 3 years ago, 15 are living, 9 lost, and 47 dead (absolute percentage of 3-year cures, 21.1 per cent; percentage of cures among traced cases, 24.2 per cent). Of the 58 cases of true carcinoma treated at least 3 years ago, 47 are dead, 7 are lost, and 5 are alive and well (absolute percentage of 3-year cures, 8.5 per cent, percentage of 3-year cures among traced cases, 9.8 per cent).

A detailed summary of the results is given in Table I.

These results are to be compared with those of the following:

1. Norris and Vogt (52) of the University Hospital, Philadelphia, reported 37.5 per cent alive in a series of 56 cases in which a complete record existed over 3 years.

2. Byron and Berkoff (9) of the Woman's Hospital, New York, reported 12 of 82 cases (14.5 per cent) living 6 months to 9 years, which is quite comparable with the 19.7 per cent reported in the present series alive 6 months to 8 years.

3. Mayfield (39) of the Mayo Clinic reported a series of 100 cases of "papillary cystadenoma," of which 39 were dead, 23 lost, and 38 living (4 possibly with recurrence) at an average of 7½ years after the operation.

4. Codman (10) of Boston reported 5 cases of his own of "malignant peritonitis of ovarian origin" that had remained well over long periods and added 2 more cases from a series of 41 patients operated upon at the Massachusetts General Hospital for carcinoma of the ovary with metastasis who had lived at least 4 years. The exact pathology of these tumors was not definitely described and several noted as "colloid" in type might have been pseudo-myxoma.

5. Pfannenstiel (56) of Kiel noted after 4 years a recurrence in 74 per cent of the cases (83.3 per cent for papillary carcinoma and 66 per cent for the non-papillary), but was able to report a rate of only 14.64 per cent 5-year cures.

6. Glockner (17) of Leipzig reported that 29 per cent of the cases which were observed 5 years were free of recurrence.

7. Doederlein (11) of Munich found 10 of 72 patients alive but only 6 had passed 5 years.

8. Schaefer (67) of University Clinic, Berlin, reported 17.14 per cent of 5- to 10-year cures among 70 cases of primary carcinoma in which operation was attempted, but an absolute percentage of 13.1.

9. Stuebler and Brandess (75) of Tuebingen found 24.5 per cent of 122 cases alive and well over 3 years, an interval which they considered sufficient, since in their experience practically all recurrences took place within that time.

Studies of any considerable number of cases treated with operation and radiation or radiation alone are infrequent, but one or two reports indicate a definite improvement when these methods are employed.

10. Strassmann (74) of Berlin reported 32 cases of ovarian carcinoma treated by operation alone, of which only 2 could be found alive after 1 year, while of 20 cases receiving postoperative radiation, 10 had passed 2 years, and 2 were well over 6 years.

11. Heyman (25) of Stockholm reported detailed results as follows on cases treated by radiation, usually intra-uterine or intravaginal radium and external X-ray. Of 13 inoperable cases, 2 were alive 1 year; of 14 recurrent cases, 2 were alive 2 years; of 15 cases incompletely operated upon 2 years previously, 40 per cent were alive and of 7 similar cases, 42.9 per cent were still alive after 5 years; finally, following complete operation, 66.7 per cent were alive 2 years and of 5 cases treated 5 years before, 4 were still alive. Heyman as well as Strassmann emphasizes the removal of as much of the tumor as possible before radiation.

It will be seen that the percentage of definite cures varies from close to zero to about 40 per cent, a variation which it seems must be due in part at least to the exact pathological types admitted by the pathologist to the category of malignancy. It should be noted that in the Roosevelt series only 39 per cent of the definite carcinomata were limited even to the ovaries, tubes, and uterus, and as this represents practically the entire group from which surgical cures may be hoped for, it seems probable that the reports of over 30 per cent must be based on a slightly different classification. The histological borderline between some papillary cystadenomata and the early carcinomata is very vague, and since these are the cases from which recoveries are likely to occur, the shifting of a few cases one way or the other according to the personal attitude of the pathologist may greatly weight the end-results for better or for worse.

PROGNOSIS

The problem of prognosis may be approached from several angles.

I. *Histology.* This study indicates the following points:

1. The simplest types of epithelial new-growths, fibro-adenoma, and the less active type of papillary cystadenoma never show

metastasis or implantations and are always benign, although a similar growth may later develop in the opposite ovary. Furthermore, it seems probable that if not removed, the papillary cystadenoma may at times go through a series of changes in form until they develop malignant qualities.

2. There is a hyperplastic type of papillary cystadenoma easily confused with carcinoma that occasionally causes multiple implantations on the peritoneum which, however, the pathologist can assert will probably regress after bilateral oophorectomy. In this type the histology is the essential point in prognosis.

3. Once the diagnosis of carcinoma has been established beyond a doubt, the ultimate fate of the patient depends little upon histological degrees of malignancy, for as soon as the growth has extended beyond the pelvic organs, uniformly bad results are obtained surgically in all varieties. In two points, however, the histology conforms with the clinical measures of malignancy. In the first place, the duration of life appeared to be somewhat influenced by histological structure, the average time from operation to death being for Grade I, 21 months; for Grade II, 5½ months, and for Grade III, 13 months. Second, the histological degree of malignancy was somewhat proportional to the stage of gross extension of the disease as indicated by the following table which shows the percentage of cases in each grade in which the tumor process had extended beyond the ovary.

	Per cent
Papillary cystadenomata	13
Grade I carcinoma	54
Grade II carcinoma	83
Grade III carcinoma	64
Miscellaneous carcinoma	81
Total for all carcinoma	73

It should be noted that here, as elsewhere, Grade III (completely undifferentiated functionally) shows slightly less malignancy than Grade II with its greater nuclear irregularities.

II. *Gross distribution in relation to prognosis in the malignant cases (exclusive of papillary cystadenoma).* The gross extension of the disease may be considered in four stages: the prognosis for each stage being roughly indicated by the following results:

TABLE II.—RELATION OF AGE TO DEGREE OF MALIGNANCY

	All tumors			Serous papillary tumors		
	Each type in age groups, per cent			Each type in age groups, per cent		
	Puberty to 38	38 to menopause	Menopause and over	Puberty to 38	38 to Menopause	Menopause and over
Papillary fibro-adenoma	44	33	22	44	33	22
Papillary cystadenoma	31	43	26	38	43	19
Carcinoma—Grade I	21	21	58	44	11	44
Carcinoma—Grade II	18	28	54	0	30	70
Carcinoma—Grade III	20	20	60	18	18	64

1. *Disease limited to one ovary:* of 19 cases, 6 patients are alive at least 6 months, and 3 of them are alive over 3 years.

2. *Disease limited to both ovaries:* of 5 cases, 3 are alive at least 1 year, and 1, 3 years.

3. *Disease beyond ovaries but limited to uterus and tubes:* of 10 cases, 6 are alive at least 6 months but none has yet reached 3 years.

4. *Disease beyond female pelvic organs:* of 64 cases, only 1 is alive, this case being in good health 4 years after an operation requiring partial removal of the omentum.

From the statistics it may be said that of the cases apparently limited to the removable pelvic organs, nearly half (44.1 per cent) have at least a fair prognosis, while cases in which the disease has progressed further are almost hopeless.

The bad prognosis of bilateral as compared to unilateral carcinoma has always been emphasized. Thus for example, Schaefer (67) found recurrence in 97.8 per cent and Glockner (17) in 100 per cent of bilateral cases. Yet it seems probable that these very bad figures for bilateral tumors must be partly attributed to the fact that this group contains most of the cases with the generalized peritoneal carcinomatosis and the prognosis for simple bilateral tumors does not appear quite so unfavorable when the cases with metastasis are separated from them.

Ascites in itself seems from these studies to have rather little direct bearing on the prognosis, since 2 of the 5 3-year cures each showed several quarts of peritoneal fluid, this being

sanguineous in one instance. Ascites, is, of course, more frequent in the advanced cases.

III. *Age.* There was some distinct evidence that the younger patients had a slightly better prognosis. In the first place, the degree of malignancy appeared to be proportional to the diminution of the ovarian function. In order to show the age relationship, the cases have been divided into three groups depending upon the theoretical state of the ovarian function. The first group includes all those cases from puberty up to 38 years of age, during which time the ovarian function must be said to be relatively high; the second group between the years from 38 to the menopause, during which time the ovarian function is on the wane; and the third group, all those which have passed the menopause, at which time the ovarian function becomes markedly deficient. This classification based on physiological age, even though it only approximates the true condition, seems to be far more logical, particularly in the study of gynecological conditions, than the customary arbitrary division of cases into decades.

Table II shows the relative frequency of carcinoma Grade I and papillary cystadenoma among young women and the similarly high proportion of carcinomata of the second and third degree among women who have passed the menopause. This relation of increasing age to degree of malignancy was more apparent in the typical papillary serous cystadenomata and carcinomata than in the mucous and glandular tumors, a fact which may be of significance.

It has appeared to us also that to a small extent the younger women had a slightly better prognosis aside from the difference in the degree of malignancy to which they are disposed. In the first place, of the 4 patients with papillary cystadenomata with ascites or implants, who recovered, all were under the menopause and 3 under 38. Of the 5 patients with true carcinoma who have lived over 3 years, 2 are under 38 (a third under 38 died of pneumonia at 2 years), 1 other case is under the menopause, and only 2 have passed it.

IV. *The form of operation in relation to prognosis.* The relation of the type of operation to the result is not amenable to statistical analysis in this series, because in almost every instance in the treatment of the malignant cases, partial operation was resorted to only when the technical difficulties offered by an extensive growth prohibited the radical procedure. In only 1 case has a recurrence followed an incomplete operation which might have been avoided by a more extensive one. This was in a case of sarcomatous cyst which was removed without the recognition of its true nature. One year later there was a similar cyst on the opposite side as the result of the removal of which the patient died. On the other hand, in 3 of the cases in the series previous operations had been done in some other institutions at a time sufficiently near to the occasion of the development of the present condition to make it appear probable that it was a recurrence of a tumor in the ovary that had not been removed at the previous operation. It may be said then, that a complete operation favored somewhat the chances of a perfect recovery.

V. *Postoperative radiation.* The cases in our series that have received radiation, 10 in number, are too few for comparison with those that have not received it, but there is definite evidence from an examination of these cases to indicate that the duration of life following radiation is definitely increased, although we can report no cures that can be ascribed to the use of radium or X-Ray. Heyman's and Strassmann's detailed results on radiated cases are referred to elsewhere in this article.

PATHOLOGY OF PELVIC ORGANS COINCIDENT WITH OVARIAN NEOPLASMS

The pathology of the other organs of the reproductive tract was studied in the hope that this might give some insight into the general state of the genital apparatus at the time of the development of the ovarian neoplasm.

1. *The opposite ovary.* The reports on the pathological condition of the second ovary were studied in 92 cases of definitely primary ovarian growth in which full details were available for classifying the condition. The cases with such massive peritoneal involvement as to make doubtful the exact relations in the pelvis, and cases in which both ovaries had been previously removed, were excluded.

TABLE III.—CONDITION OF THE SECOND OVARY IN ASSOCIATION WITH NEOPLASMS OF FIRST OVARY

	Total	Bilateral		Previous removal of opposite ovary		Normal		Sclerotic		Cystic	
	No.	No.	%	No.	%	No.	%	No.	%	No.	%
Papillary fibro-adenoma	9	2	22.2	0	0	4	44.4	0	0	3	33.3
Papillary serous cystadenoma	15	5	33.3	2	13.3	2	13.3	1	6.6	5	33.3
Papillary serous carcinoma	34	24	70.6	4	11.8	1	2.9	3	8.7	2	5.8
Total serous tumors	58	31	55.2	6	10.3	7	12.1	4	6.8	10	17.3
Papillary mucous cystadenoma	5	0	0	0	0	4	80.0	0	0	1	20.0
Papillary mucous carcinoma	10	1	10.0	1	10.0	2	20.0	1	10.0	5	50.0
Colloid carcinoma	2	1	50.0	0	0	0	0	0	0	1	60.0
Total mucous tumors	17	2	11.8	1	5.9	6	35.3	1	5.9	7	41.3
Glandular carcinoma (including perhaps a few metastases)	12	5	41.6	1	8.4	2	16.8	1	8.4	3	25.2
Solid carcinoma (teratoma?)	3	0	0	0	0	2	66.6	0	0	1	33.3

The Table III shows the far greater tendency of the serous papillary cystadenomata and cystadenocarcinomata to be bilateral as compared with any other variety and the much greater frequency of normal ovaries in association with the pseudomucinous and solid tumors. It should be noted that of the 15 normal ovaries only 3 were examined pathologically, the others being noted as normal by the operator.

This occurrence of bilateral development in these different types is quite in accord with most other published statistics. Thus Pfannenstiel (56) reports pseudomucinous cysts as being bilateral in 17.1 per cent, the papillary serous cysts in 60 per cent, papillary adenocarcinoma in two-thirds, but solid carcinoma in only two-fifths of the cases.

II. *The fallopian tubes.* In the 70 cases associated with true malignancy of the ovary in which definite mention is made of the condition of the tubes, 35 showed cancerous involvement, 20 were normal, and 15 showed some signs of a chronic salpingitis, usually in the form of dense adhesions. The latter finding should almost certainly not be interpreted as in any sense a causative factor but rather as an inflammation incidental to the malignant growth.

III. *The myometrium.* Fibromyomata were of rather extraordinary frequency, occurring in 32 of 83 (38 per cent) of the definitely primary tumors in which the details of the history were complete and the operation such that the uterus could be satisfactorily examined. The more detailed analysis of the types of ovarian tumor associated with fibromyomata revealed the following facts:

1. Pseudomucinous tumors were accompanied by fibroids as often as the serous tumors (35 per cent and 39 per cent).

2. The more benign types of both groups were more often found to show coincident fibroids than the more malignant varieties.

3. The incidence of fibromyomata was greater in the higher age groups, the cases below 38 showing 12 per cent fibroids, the cases from 38 to the menopause 53.5 per cent, those above the menopause 45 per cent.

IV. *The endometrium.* This is a feature that deserves a careful study in connection with ovarian disease, but which cannot be done in the present series on account of the deficiency of the uterine slides. Of 23 cases in which slides were available, 3 showed a definite hyperplasia, 5 a suggestion of hyperplasia, and 15 were within normal limits. No conclusions could be drawn as to the type liable to hyperplasia. To these groups should possibly be added 5 cases of carcinoma of the endometrium associated with carcinoma of the ovary.

TABLE IV.—ASSOCIATION OF FIBROMYOMATA UTERI WITH OVARIAN NEOPLASMS

	All ages			Puberty to 38			38 to menopause			Menopause and older		
	Total	Fibroids	%	Total	Fibroids	%	Total	Fibroids	%	Total	Fibroids	%
Papillary fibro-adenoma	9	5	55.	4	2	50.	3	3	100.	2	0	0.
Papillary serous cystadenoma	15	8	53.3	6	1	16.	7	5	71.	2	2	100.
Papillary serous carcinoma	27	7	26.0	6	0	0.	7	3	43.	14	4	28.
Total serous tumors	51	20	39.	16	3	19.	17	11	64.	18	6	33.
Papillary mucous cystadenoma	6	3	50.	1	0	0.	3	1	33.	2	2	100.
Papillary mucous carcinoma	8	2	25.	2	0	0.	2	0	0.	4	2	50.
Colloid carcinoma	3	1	33.	1	0	0.	2	1	50.	.....	.....	.....
Total mucous tumors	17	6	35.	4	0	0.	7	2	28.	6	4	66.
Glandular carcinoma (incl. few metastases?)	11	4	36.	3	0	0.	3	2	66.	5	2	40.
Solid carcinoma (teratoma?)	4	2	50.	1	0	0.	1	0	0.	2	2	100.
Final total	83	32	38.3	24	3	12.5	28	15	53.5	31	14	45.1

ETIOLOGY

In a somewhat philosophical article in 1921, Gade (16) emphasized a point too often lost sight of, that whatever other factors there might be in the cause of cancer, senility was certainly an important one. He pointed out, furthermore, that particular parts of the body aged earlier than others, the female genitalia being examples of organs having an early age atrophy and that possibly for this reason carcinoma of the female reproductive tract occurred rather earlier than in other organs.

The rather high incidence of ovarian carcinoma just before or after the menopause may be perhaps partially explained on the basis of this factor of local senility and lowered function, and there are some suggestions in the literature to indicate that ovarian carcinoma in young persons has a relatively high incidence among women with hypoplastic genitalia. For example, Meyer (46) among others, has described a more or less specific alveolar carcinoma occurring in hermaphrodites, pseudohermaphrodites, and occasionally in certain other individuals. Pick (58) has noted a peculiar tubular adenoma in similar cases.

L'Esperance (34) in a recent article on embryonal carcinoma, gave histories of 6 cases, 4 of which showed marked abnormality of the ovarian function. A possible morphological explanation for this occurrence of tumors in underdeveloped ovaries is found in part of Goodall's (20) embryological studies in which it is demonstrated that interference in the vascular supply during fetal life of all or part of the ovary results in the failure of the normal atrophy of certain fetal structures and the persistence of numerous embryonal remains as fertile soil for the development of neoplasms.

Were it true that the incidence of malignant and semi-malignant conditions in older women was dependent to some extent on the physiologically lowered function of the menopause and the incidence in younger women on a congenital or early acquired hypoplasia, then there should be differences between the degree of fertility and the characteristic menstrual cycles of the women who develop these tumors at different epochs. For the purpose of searching for some such possible relationships, the cases were again divided into three physiological age groups, of full ovarian function up to 38 years, of diminishing function from 38 years to the menopause, and of deficient function above that stage. The results obtained, follow:

1. *Fertility.* Of the *married* women who developed papillary cysts or carcinoma, the following percentage at different ages have had at least one child:

TABLE V.—RELATION OF FERTILITY IN MARRIED WOMEN TO OVARIAN NEOPLASMS

	All ages			Puberty to 38			38 to menopause			Menopause and older		
	Total	Number with Child	% fertile	Total	Number with child	% fertile	Total	Number with child	% fertile	Total	Number with child	% fertile
Papillary fibro-adenoma	7	3	43.	2	0	0.	3	1	33.	2	2	100.
Papillary serous cystadenoma	11	7	64.	3	2	66.	4	4	100.	4	1	25.
Papillary serous carcinoma	29	11	38.	6	1	17.	7	3	43.	16	7	44.
Total serous	47	21	45.	11	3	27.	14	8	56.	22	10	45.
Papillary mucous cystadenoma	4	2	50.	1	0	0.	1	1	100.	2	1	50.
Papillary mucous carcinoma	5	4	80.	2	1	50.	1	1	100.	2	2	100.
Colloid carcinoma	1	0	0.	1	0	0.	.....	.....	.....	.....	.....	.....
Total mucous	10	6	60.	4	1	25.	2	2	100.	4	3	75
Glandular carcinoma	8	3	37.	3	0	0.	2	1	50.	3	2	66.
Solid carcinoma	3	2	66.	.....	.....	.....	1	0	0.	2	2	100.
Miscellaneous carcinoma	11	6	55.	2	1	50.	1	0	0.	8	5	62.
Total all forms	79	38	48.1	20	5	25.	20	11	55.	39	22	56.4

	Per cent
Under 38 (5 cases in 20)	25
From 38 years to menopause (11 cases in 20)	55
Over menopause (22 cases in 39)	56

The point in question is, of course, not the relation of ovarian tumors to the absence of pregnancy but to the physiological inability to become pregnant, and it is quite possible that some of these early cases might have later produced children had the tumor and the operation not intervened. Yet the average time married in this early group was 6 years and in all only 12 children had been produced (6 by one case). To balance the possible increase in percentage of fertile women in the earlier groups, had they been married for a longer period, is the conceivable increase in the percentage of the theoretical fertility of the older group, had some of them married at an earlier age. Definite conclusions can, of course, not be drawn from these figures on account of lack of statistics on the normal fertility ratios of women at these different ages, but there is certainly some indication that the women who developed tumors late in life had originally a more nearly normal reproductive apparatus than those who developed it in the earlier years. The detailed study of the fertility of the individual varieties of ovarian tumor revealed that in this series no particular type could be definitely said to be prone to occur in sterile women, but other statistics have revealed a decided difference. Thus Stuebler and Brandess report sterility as follows:

	Per cent
Secondary tumors	3.03
Pseudomucinous cysts	6.3
Dermoids	22.4
Papillary carcinoma	20.4
Papillary serous cysts	25

The relation of the tumors in the present series to fertility follows:

2. *Menstruation.* For the purpose of comparing the menstrual peculiarities, those cases were considered more or less arbitrarily as atypical in which the characteristic (i.e., original) cycle showed periods coming more often than every 26 days or less often than every 30 days and those in which the duration was less than 3 or more than 5 days. On this basis, the following percentages of cases with atypical menstrual cycles were found at the ages indicated:

	Per cent
Under 38 (12 of 26 cases)	46.1
30 to menopause (13 of 29 cases)	44.8
Above menopause (9 of 30 cases)	30.3

Taking, however, those cases in which there was only an abnormally long interval or short duration, the following results were obtained.

TABLE VI.—MENSTRUAL CHANGES ASSOCIATED WITH OVARIAN NEOPLASMS

	Total	Per cent
Puberty to 38—26 cases		
Increase in frequency or duration	6	23.0
Decrease in frequency or duration	11	42.6
Total change	17	65.6
Age 38 to menopause—29 cases		
Increase in frequency or duration	11	38.0
Decrease in frequency or duration	12	41.4
Total change	23	79.4
Over menopause—38 cases		
Return of menstrual bleeding	5*	13.2
Decrease	0	00.0
Total	5	13.2

*Includes 2 cases associated with carcinoma of fundus uteri.

	Per cent
Under 38 (8 of 26 cases)	30.7
38 to menopause (4 of 29 cases)	13.8
Over menopause (4 of 30 cases)	13.3

Here again the statistics and especially the inability of the older women to remember the minor irregularities of years before may lead to an error, but there is once more a suggestion that the young women who develop ovarian neoplastic disease have a definitely lower inherent ovarian functional capacity, as indicated by menstrual irregularity than those which developed the disease after the physiological decline in activity. Studies of the separate varieties of tumors in relation to menstrual irregularities gave no additional information, although a larger series might yield significant figures.

Some change in the form of menstruation, appearing shortly before the entry of the patient into the hospital, is also very common. This manifests itself sometimes in an increase, sometimes in a decrease in the duration and frequency. It usually has its onset near enough to the time of the operation to indicate that it is possibly a result of the tumor and not associated with the cause of it, although sometimes it may antedate the development or at least the actual discovery of the tumor by several years, as in the case of a girl 22 who had had an amenorrhœa for 2 years before the operation. This change in type occurring shortly before the operation must be strongly differentiated from the abnormality of the individual's characteristic menstruation, as discussed above. That these new abnormalities are not all due to the ovarian growth is obvious when the high percentage of fibroids in the group is considered and when it is also remembered that in the middle group in particular the effect of the menopause is being felt. Furthermore, it should be explained that the standard history form used on the Roosevelt Gynecological Service requires searching inquiries into menstrual changes, small variations being often thus noted, which would not otherwise appear among the presenting symptoms. The statistics in the accompanying table include such minor variations and yet it must be concluded that the majority of patients on entering the hospital are suffering from some disturbance of the ovarian function, whether pathological or physiological.

The evidence in favor of the existence of a strong constitutional factor in the origin of ovarian neoplasms is, therefore, based on the following points:

1. The frequent occurrence of ovarian new-growths, especially of the more malignant varieties, at or near the menopause.

2. The relatively high percentage of sterility and menstrual disorders in the women who develop a new-growth before the time of the normal decline in ovarian activity.

3. The constant increase in the average degree of histological malignancy with increase in age and the diminution of physiological capacity.

4. The frequency of multicentric origin of ovarian tumors, in the sense of bilateral papillary cysts and of multiple papillomata in the various chambers of a multilocular cyst and possibly also in that of coincident uterine carcinoma.

5. The common association of ovarian growths with cystic ovaries and with fibromyomata uteri, both of which conditions are probably indicative in themselves of slight sexual deficiency.

Most of these facts as outlined, pertain especially to the serous group of tumors, which is especially interesting when it is considered that carcinoma of the uterine fundus, an histologically related type, has many comparable features in its etiology. Thus in a report of 186 cases of fundus carcinoma, Mahle (37) gave the following figures: average age of incidence, 55.1 per cent; sterility among married, 33.3

per cent; coincident fibromyomata, 35.4 per cent. These similarities in etiology are of particular note in view of the current theory of origin of some ovarian cancers from heterotopic endometrial tissues.

TREATMENT

Early diagnosis is almost impossible in most cases on account of the long symptomless period of the disease and the considerable extent to which the process has already attained when the patient first becomes aware of anything being wrong. Periodic gynecological examination offers probably the only hope of detecting any considerable number of early cases.

Ovarian cysts, even when believed to be benign, must be tentatively regarded as precancerous and removed as soon as possible, for in all cases a papillary process may be present within the cyst or may be on the point of developing. Ovarian cysts in older women should cause particular suspicion of malignancy.

In the probably malignant cases with ascites, exploratory operation is still indicated, for some of these patients are without peritoneal metastasis and may recover especially in the earlier age group.

In the still more advanced cases, no matter what the size of the cyst, and even when peritoneal implants are thought to be present before the operation, exploration should still be made in the hope that the neoplasm will be localized or that it will be of a histological type that will regress after hysterectomy, and also for the reason that radiation therapy may be more satisfactory after at least a part of the tumor mass has been removed.

The contra-indications to operation are the following:

1. Marked cachexia which renders the mortality from operation inordinately high.

2. Fixity of the pelvic structure indicating the probability of the existence of an almost insuperable technical obstacle to hysterectomy.

3. Large masses in the upper abdomen, which may indicate that the ovarian growth is secondary to a gastric tumor or that a primary growth is relatively far advanced. In this series the tumors with relatively benign histology formed only tiny implants (the conventional term in the reports of similar cases being a "peppering" of the peritoneum) while the larger solid masses were invariably formed by a highly malignant growth rendering the condition in consequence quite hopeless.

4. The presence of gastro-intestinal symptoms which with roentgenological examination indicate the probability of a primary tumor being present somewhere in the alimentary tract.

The type of the operation depends on the nature of the tumor and the age of the patient:

1. In the malignant papillary carcinomata, the procedure is invariably hysterectomy and the removal of both tubes and ovaries even though only one side is visibly diseased.

2. In sarcoma and teratoma occurring in very young women, the strong tendency of these tumors to remain for some time unilateral may be considered a sufficient justification to limit the operation to a unilateral salpingo-oophorectomy, if the disease is still strictly localized.

3. In the case of a unilateral serous cyst of the benign type with only a relatively small number of warty papillæ in the cyst, the opposite ovary after careful examination may be left in a woman under 35 years, but if it is at all cystic the strong tendency of the disease to develop bilaterally must be remembered and all factors weighed before one ovary is allowed to remain.

4. In the cases of pseudomucinous cyst, on the other hand, since these tumors also tend to remain unilateral, if the opposite ovary is grossly normal and the papillæ of the cyst are relatively small or limited to a few loculi and there are no hard nodules in the cyst wall, the opposite ovary and the uterus may be preserved.

The question of complete or supravaginal hysterectomy is a debatable one, though it appears from our observation that there are few cases in which the course of the disease can be greatly affected by the larger operation. It should, however, be performed when it does not add greatly to the difficulties of the procedure.

Omental nodules discovered after laparotomy, if not numerous, may be removed if the condition of the patient permits, but the

resection of organs secondarily involved, such as bladder, colon or sigmoid, appears from our statistics to be a dangerous and futile procedure.

Postoperative radiation should never be omitted in any malignant case. The cases so treated in this series have been too few to permit conclusions to be drawn, but some clinics report definite improvement in their results by using postoperative deep X-ray therapy, and it will be used routinely on the Roosevelt service in the future.

Treatment by external X-ray with intravaginal or intrauterine radium should also be tried in the moderately advanced inoperable cases, in the hope that the growth may prove radiosensitive. Occasionally, inoperable cases are rendered operable, and even isolated cures have been reported by this method. Furthermore, it seems probable that, unless the patient's general condition is already so poor as to render the radiation immediately dangerous, a definite prolongation in the duration of life can be obtained in most cases.

GENERAL SUMMARY AND CONCLUSIONS

1. This study is based upon a clinical and histological review of 139 cases of tumors diagnosed as papillary cystadenoma, primary carcinoma, and sarcoma of the ovary.

2. The present view of the origin of primary epithelial tumors of the ovary indicates that a certain mixed group is of teratomatous origin and that this group possibly includes the pseudomucinous tumors, while the common serous cyst and its hyperplastic and malignant varieties arise from the germinal epithelium or abnormally placed endometrial tissue.

3. A study of these types of ovarian tumors in their various stages of hyperplasia and malignancy is given with a description of the histology and the end-results in each group.

4. As regards the histological criteria of malignancy, it is found in ovarian tumors that loss of differentiation does not carry with it so severe a prognosis as the presence of marked nuclear irregularity, even though the latter occur in tumors the structure of which shows moderate functional differentiation. For this reason, Group III of completely undifferentiated cells showed slightly better results than Group II partially differentiated but with marked nuclear irregularity.

5. The operative mortality depends chiefly on the selection of the cases. In this series the mortality was 11.8 per cent for the true carcinoma, and 2.2 per cent for the semimalignant papillary tumors.

6. The percentage of late cures reported depends partly upon the pathologists' conception of where to draw the line of malignancy. Of the positively malignant cases that have passed 3 years, the absolute percentage of cures in this series is 8.5 per cent while if the actively growing papillary cystadenomata are included, the results become 21.1 per cent, in each figure the untraced cases being counted as dead.

7. Prognosis is vitally dependent upon histology only in the unusual type that may cause peritoneal implantations and regress after complete hysterectomy. This variety may be in the nature of a hyperplasia of a peritoneal endometriosis.

8. Prognosis, however, depends almost directly upon the degree of the extension of the growth, for when there is a cancer beyond the ovaries, uterus, or tubes, the results are always bad with the exception of a rare cure with the aid of X-ray.

9. The younger the patient the more benign the histology is liable to be.

10. The pathology of the generative organs associated with these ovarian tumors includes a high percentage of fibromyomata, frequent cystic degeneration of the uninvolved ovary when the disease is unilateral, and at times possibly a hyperplasia of the endometrium.

11. As possible etiological factors in the development of ovarian carcinoma are the physiological, diminished function of the menopause and a congenital underdevelopment in women who developed the disease early. In substantiation of this, figures are given showing the lower fertility and the scantier menstruation in younger women with ovarian tumors.

12. The treatment, if possible, should be complete hysterectomy with removal of both ovaries (except in rare instances) and postoperative radiation should invariably be given in the malignant cases.

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STONE. Krukenberg Tumor.
ROBINSON and SEMB. Endometriosis.

CRANIAL CHANGES ASSOCIATED WITH MENINGIOMA "DURAL ENDOTHELIOMA"[1]

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WHILE the frequent presence of changes in the skull overlying a meningioma is well known, the nature of these changes is still under discussion. The view that the localized thickening of the skull is the primary tumor with the meningioma proper as a secondary intracranial extension, is at present entirely abandoned. Notwithstanding the fact that in 1906 Barling and Leith (1) showed the presence of tumor cells of the meningioma type throughout the bony thickening, the latter was looked upon as a simple cranial hyperostosis which resulted from an irritation by the underlying dural growth. Only since Cushing's contribution of 1922 (2) has the fact generally been appreciated that the thickening of the skull overlying a meningioma is infiltrated by tumor.

Cushing's report was soon followed by other studies, the foremost of which were those of Phemister and of Penfield. In a discussion of the nature of the cranial changes, various investigators departed from an *á priori* accepted view which has never been definitely proved; they believed that bone proliferation follows upon, and is a direct result of, the infiltration of the skull by tumor cells. As Cushing expresses it: ". . . under the influence of intracranial tension the tumor cells in the process of their multiplication become crowded into and through the vascular dural spaces and finally into the canaliculi of the bone. In consequence of this, the bone becomes irritated with subsequent osteoblastic proliferation which provokes the hyperostosis" (p. 148). The conclusions reached have been influenced by this view. That the knowledge of the character of these osseous changes and of their mechanism of production is nebulous and confusing, one may judge from a study of the contributions to this subject. Thus, Penfield (4), referring to the intracranial and cranial portions of the neoplasm, says: "It seems most unusual that in one part of a neoplasm osteogenesis should occur, while in the other part there is none." Phemister (5) states on page 566: "It (the new bone) grows out of the old bone." In the summary on page 572 he concludes: "The new bone is not tumorous in nature, and is usually ossified stroma of the invading endothelioma." It is evident that the last two statements contradict each other, since if the new bone grows out of the old bone, it cannot represent "ossified stroma of the invading endothelioma." Then again, if one admits that the stroma of the cranial portion of the tumor does ossify, how is it that the intracranial portion, and for that matter also the extracranial portion of the tumor, after the latter perforated the skull, does not ossify to any appreciable extent?

The accepted opinion that the proliferation of bone is a result of its stimulation by the infiltrating tumor cells, has influenced the studies of this subject in yet another way. One usually hears of proliferative processes in the overlying skull, but the fact that destruction of bone accompanies the proliferation in most cases, has received little appreciation, as one can see from the titles of the studies in which the authors refer to "cranial hyperostosis" or "osteoma."

A study of the bone flaps and the tumors removed from ten patients with meningioma, at the National Hospital, Queen Square, London, leads me to believe that the assumption that the thickening of the bone is a result of irritation of the latter by infiltrating tumor cells is erroneous. The bone proliferation precedes the actual infiltration of the bone by the tumor cells, and probably is a result of an early, especially slowly progressing dilatation of the blood vessels in the portion of the cranium overlying the meningioma, while the subsequent infiltration of the bone by tumor leads to bone destruction.

The fact that *local* changes in the skull overlying an intracranial tumor are observed almost exclusively in meningiomata and are not seen in cerebral gliomata suggests a leading

[1] From the National Hospital, Queen Square, London

question: How does a meningioma differ from other brain tumors in its relation to the overlying skull? The fact alone that in meningioma the tumor is attached to the dura is insufficient for an explanation of the cranial changes, since occasionally gliomata reaching the cortex adhere to the overlying skull. The foremost difference is the blood supply. While gliomata are supplied by cerebral blood vessels, meningiomata depend upon meningeal blood vessels for their supply. The wide communication of the meningeal veins with the diploic veins is the anatomical basis upon which rests the influence of a meningioma on the overlying skull. The meningeal veins, which are easily collapsed under local pressure, would be insufficient for the blood supply of the growing neoplasm if it were not for these communications. The latter lead to a marked enlargement in size and increase in number of the diploic veins in the cranium close to the tumor. Without appreciation of this radical difference of the blood supply of a meningioma from that of other cerebral tumors, Elsberg and Schwartz (5) arrived at the same conclusion from studies of radiograms of random cases of intracranial tumors. To quote these authors: "We have, therefore, arrived at the conclusion that if the diagnosis of brain tumor has been made, and unilateral enlarged diploic channels are found in the general area in which the tumor is suspected, there is considerable probability that the new-growth is an endothelioma."

When the radiological evidence of dilated blood vessels is correlated with microscopical studies of sections passing through the entire affected area of the skull overlying a meningioma, one is impressed by the fact that these dilated blood channels are present mainly in the periphery of the affected portion of the bone (Fig. 1). It is in the periphery that it is best to study the early changes in the bone that follow such a dilatation of the blood channels, for nearer the center these changes are too far progressed to allow a reliable analysis. Approaching this periphery from areas of normal skull one may see in the bone the appearance and progress of two changes that go parallel; a dilatation of blood channels and an apposition of new bone on the internal and external surface of the skull. This dilatation of blood vessels is not limited to the diploe but is outstanding in both plates of the bone. The proliferation of new bone is most striking on the internal and external surfaces of the skull, where it is easily distinguishable as layers of new bone superimposed on one another. The increase of the degree of dilatation of the blood channels toward the central portion of the affected area of the skull parallels the increasing amount of new bone.

These findings are most convincing although it is difficult without speculation to explain the relationship between dilatation of blood channels and bone proliferation. Our present knowledge of osteogenesis is limited to hypothetical considerations, many without actual facts to support them. It is evident that had this dilatation of blood channels progressed more rapidly, it would have resulted in mere destruction of bone but the extremely slow dilatation of these channels is most likely a process stimulating proliferation of bone, whether it be by keeping the periosteum under increased tension, because of venous stasis in the bone, or through other unknown factors.

Advancing, in the microscopical study, from the periphery to the center, one can follow the varying extent of infiltration of the overlying skull by tumor cells. First, they appear in the diploe. Because of less resistance, the cells spread here farther than in the adjoining external or internal tables (Fig. 2). Soon, however, tumor cells are noticed in the internal table and in the new bone about it. Finally, in an area nearer the center, the tumor cells are seen in the external table and in the adjoining new bone. After the tumor cells have made their way through the external table, they spread through the soft coverings of the skull far more extensively than in the external table (Fig. 3). The tumor cells show a tendency to spread along lines of lesser resistance; thus, aside from filling the enlarged haversian canals and dilated blood spaces, they spread between the bony lamellæ, frequently emphasizing by this the separate layers of the new formed bone. This "passiveness" of the tumor cells is also well seen in the infiltration of the soft tissues covering the skull; after the tumor cells have perforated the bone they spread along

fascial planes and through areolar connective tissue spaces, compressing rather than destroying the surrounding normal structures. In view of this passiveness of the tumor cells it is preferable, in speaking of meningioma, to use "infiltrate" rather than "invade."

The passiveness of the tumor cells does not preclude their ability to destroy bone after they have spread throughout its canals and lacunæ. Histological studies show various phases in this bone destruction, which, viewed largely, does not differ from destruction of bone by any other mesoblastic tumor spreading in it. The tendency of the tumor cells to multiply though enclosed in bony chambers, leads to gradual pressure absorption of the walls of these chambers. Occasionally one encounters an active bone destruction which is accomplished through the assistance of normal osteoclasts. This active destruction, however, is rare. The dense bone of the tables proper is extremely resistant to destruction, so that even in the advanced cases of cranial changes one may easily distinguish the outlines of both tables microscopically as well as in the radiogram of a slice of the removed bone flap (Fig. 5). Destruction of the new formed bone on the intracranial side of the skull may lead to irregular jagged excrescences of bone surrounded by soft tumor (Fig. 4).

The arrangement of the new formed bone is of some interest. The most frequent arrangement is in layers parallel to the surface of the skull. This arrangement of bone is readily understood if one considers the periosteum responsible for its production. The parallel striation of the new formed bone can be appreciated only in microscopical studies, while in the radiogram they cannot be distinguished because they coalesce in the shadow. Occasionally, the new bone is arranged in spicules perpendicular to the surfaces of the skull. On the cut section of the gross specimen, one sees numerous dense glistening striæ which are closely aggregated at their base on the bone surface and arranged perpendicularly to the external and internal table of the skull. Topographic-microscopical studies show bands of connective tissue which divide the proliferated new bone into radiating columns by dipping into it at irregular intervals. Blood vessels frequently accompany these bands, and between them numerous dainty spicules of bone are seen running perpendicularly to the tables of the skull. It appears as though the course of the blood vessels and bands predetermines the course of the bony spicules. Phemister expressed an opinion that the new formed bone is always arranged to support the tumor. Histological evidence does not support this view. When present, the perpendicular arrangement of the bony spicules is found also in the periphery where no infiltration of tumor cells is seen, while in the central portion of the affected bone area where tumor is seen in abundancy, bony spicules are less abundant (Fig. 5).

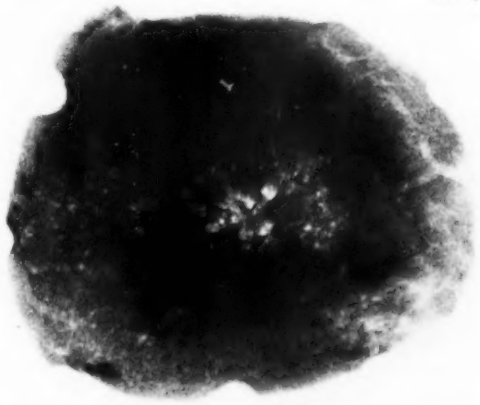

Fig. 1. Roentgenogram of a bone flap overlying a meningioma. Note the widely dilated diploic veins in the periphery.

The degree of bone proliferation and the amount of new formed bone vary greatly with each case. Cushing pointed out the fact that the proliferation of new bone is greatest in the flat variety of meningioma, the so-called meningioma *en plaque*. Three cases of meningioma *en plaque* in the present series support this observation. The dilatation of vascular channels in these three cases extended over a much wider area than in the ordinary spherical meningioma. Microscopically the infiltration of bone by tumor cells was really negligent, extending over a smaller area and permeating only the intracranial portion of the bone. This wider and more extensive dilatation of the blood channels of the overlying skull coupled

Fig. 2. Photomicrograph of a section passing through half of the bone flap shown in Figure 1. The diploic blood spaces are filled with tumor cells. New formed bone is seen about the internal and external tables of the skull. The involvement of the internal table by tumor is less extensive than that of the diploe but considerably more extensive than that of the external table. ×4.

with the negligent infiltration of the bone by tumor cells probably is an important factor in intensive proliferation of bone.

Naturally, a question arises as to whether there is any relationship between the cranial changes and the cellularity of the underlying tumor. Histological evidence points against such a relationship. Extremely cellular tu-

Fig. 3. The tumor cells have made their way through the skull. The tumor spreads through the soft tissue covering the skull more extensively than in the external table. ×4.

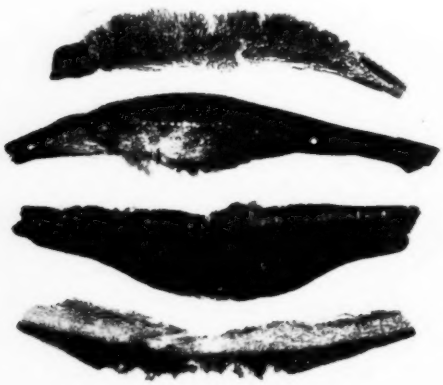

Fig. 4. Roentgenograms of thin slices of skull over meningiomata in four cases. They show jagged excrescences of bone surrounded by soft tumor on internal surface of skull.

Fig. 5. Roentgenogram of a slice 1 centimeter thick of the skull overlying a meningioma. Notwithstanding the extensive destruction of bone, the outlines of both tables are shown well. In the central portion of the affected bone area where tumor was present in abundancy, bony spicules are scarce.

mors are seen where bone proliferation is strikingly great, but fibrous, relatively acellular tumors are encountered along with extensive destruction of the overlying cranial boss.

An interesting relationship is that between the proliferative cranial changes and the patient's age. It seems that the age of the patient is of some importance in all pathological conditions having osteogenesis as one of the main features; osteogenesis is better expressed in patients who are below or just at the age of completion of growth of the skeleton. It is, of course, hardly possible to draw reliable conclusions from so small a series of cases as the present one. However, the proliferation of bone was definitely more in evidence in all patients below thirty years of age, that is, in five cases out of the ten studied.

The clinical incidence of cranial changes in meningioma has been placed by Cushing at not less than 25 per cent of all cases. The fact that such changes were present in all ten cases of the present series is inconclusive, since these cases were chosen and not taken at random. A reliable figure as to the clinical incidence will be impossible to give as long as the skull overlying meningioma is not studied radiologically and histologically in every case.

SUMMARY AND CONCLUSIONS

To draw reliable conclusions from microscopical evidence of the cranial changes associated with meningioma, one must study sections from the entire overlying portion of the skull and not merely from the central, most changed portion.

Proliferation of bone precedes the infiltration of the skull by tumor cells. This proliferation follows on the heel of a local dilatation of the vascular channels in the skull; it is probably a result of a defensive reaction of the bone to this slow, progressing dilatation of the blood vessels.

Infiltration of the bone by tumor cells takes place subsequent to the commencement of the formation of new bone; it leads to bone destruction and occasionally to complete perforation of the skull.

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A STUDY OF THE PERIPHERAL ARTERIAL CIRCULATION IN ARTERIOSCLEROSIS AND GANGRENE

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GANGRENE of the extremities is all too common an accompaniment of peripheral arteriosclerosis. It is dependant upon the cutting down of the caliber both of the main arterial trunks and the anastomotic branches by an obliterating endarteritis or sclerosis.

This study was made to determine, if possible, the caliber and condition of the various main arteries of legs amputated for gangrene.

In a series of seven cases of amputation for gangrene of the feet, we have been able to demonstrate loss of continuity and diminution in size and number of anastomosing vessels due to sclerosis. In this small group the changes are extreme. Obviously this must have been so to have produced gangrene. It is remarkable (yet obvious) how widespread and pronounced this change may be and yet cause no circulatory failure until it shuts off the blood stream from all sides. This can happen in toes more readily as they are peninsulas of flesh, as it were, with restricted areas from which they can receive anastomotic supplies.

Frequently the peripheral vessels, especially the popliteal, dorsalis pedis arteries, etc., are calcified and show as slightly irregular, beaded pipe stems in X-ray films. Often this is used as an index of the extent of the sclerosis. In this study we have been amazed at the profound changes present throughout the arterial system in the seven legs which were dissected. It was much more extensive than was indicated in the films by the calcification of a few vessels. Of course extreme changes were expected near the gangrenous area which showed no very extensive calcification in the arterial walls. In the films made after injection of the arterial system with barium sulphate solution, the general extent of the sclerotic process was very evident.

Although some attempts to show the arterial circulation during life have been reported, this procedure is not without danger. This is especially so if an irritative substance as most concentrated solutions must be, is introduced into the channels of arteries already badly damaged. Many of the arteries dissected out after amputation showed recent sclerotic changes evidently tending rapidly toward destruction of the wall and occlusion. This type of lesion should dissuade one from using any but non-irritating substances for any attempt at demonstrating vessels *in vivo*.

METHOD

Films taken previous to operation were studied for calcification of vessel walls to gain some idea of the extent of the arteriosclerotic process. The amputated legs were taken still warm from the operating room, and the femoral artery was dissected free. An adapter for a record syringe was tied into the lumen of the artery. A thin suspension of barium sulphate —a heaping teaspoonful stirred into about 8 ounces of warm water or salad oil—was injected with a syringe into the artery, under considerable pressure. Blood vessels at the cut end of the limb were allowed to empty themselves of blood and serum until a full stream of the barium suspension issued from them. They were then clamped or tied off. The injection was continued until no more material could be forced in by hand pressure on the plunger of the syringe. By this time some of the skin vessels were injected and the extremity became quite pale, though still warm. The artery was tied below the adapter.

X-ray films were now made in the usual positions or at any chosen distance or position. The films shown here were taken at 25 inches target film distance, and a Bucky diaphragm and screens used (Figs. 1 and 2).

The arteries were dissected out immediately following this, while the leg was still warm. The inner diameter, or the caliber of the artery, was measured in millimeters by means of calibrated brass rods. These measurements

Fig. 1. Lateral view of lower leg and foot following barium injection of the arterial system immediately after amputation showing large gaps in the lumen of main vessels due to sclerotic changes, poor anastomotic network, gangrene of fourth and fifth toes.

Fig. 2. Lateral view of I. H. showing poor anastomotic circulation, and fine, tortuous arteries with irregular lumina. Appearance of arteries in film borne out by dissection.

were obtained at the following points: Popliteal, 3 centimeters above origin of anterior tibial; anterior tibial, 1 centimeter below point of origin; posterior tibial, 1 centimeter below point of origin; peroneal 1 centimeter below point of origin; peroneal at point of bifurcation from posterior tibial (Table I).

The arteries were also dissected out in the regions shown in the film to be defective and searched for clots. In all seven of the extremities studied here the defect has been found to be in the artery wall with partial or total occlusion as depicted in the films. At no point were clots found in any of the larger vessels. The finer vessels, i.e., under 1.0 millimeter, were not measured for this study chiefly because of their multiplicity.

The same points in the arteries mentioned above, as nearly as possible, were measured in millimeters with a micrometer directly on the X-ray film. This measurement, as the film is made at the 25-inch distance and the vessels are only an inch or two from the film, is distorted a small percentage at the most. As there is apt to be some change in diameter of the vessel from the handling during dissection, cutting across for the insertion of the measuring rod, etc., these measurements are also apt to be in error, depending upon the amount of trauma and cooling, etc. This might vary considerably from vessel to vessel. On the other hand, a warm solution containing insoluble non-toxic barium sulphate injected under pressure should distend all the vessels of about the same caliber uniformly. Measurements therefore of the shadows of barium inside the vessels in the X-ray films should be comparable. If the amount of distortion is taken into consideration, these measurements

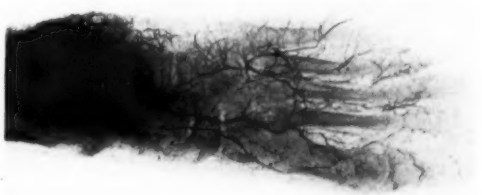

Fig. 3. Anteroposterior view of left foot of I. H., showing poor vascular supply to all of the toes, gangrene of the fifth toe, mummification of part of the fourth toe, atrophic changes in nails of the other toes, osteoporosis of the phalanges, cold extremity.

TABLE I. COMPARATIVE MEASUREMENTS OF ARTERY CALIBER IN MILLIMETERS

	Popliteal		Ant. Tibial		Post. Tibial		Peroneal		Dorsalis Pedis	
	X-ray film	Brass rod	X-ray	Rod	X-ray	Rod	X-ray	Rod	X-ray	Rod
J.B. 13824	4.0	3.9	2.0	2.3	0	0	0	0	2.0	.....
I.H. 6578	2.0	1.9	1.6	2.0	1.0	1.3	1.0	1.0	1.2	.....
I.G. 9567	4.1	2.3	2.5	1.5	3.0	2.7	1.5	1.5	1.0	.....
E.M. 2555	1.5	0	3.0	1.5	0	0	2.8	3.0	0.1	.....
J.B. 12672	2.0	2.3	2.0	2.7	0	0	0	0	1.0	.....
A.S. 8414	5.5	6.2	4.0	3.9	2.8	3.0	2.0	3.0	2.5	.....
H.M. 9812	2.3	2.3	2.0	1.5	1.0	1.2	1.0	1.2	1.5	.....

should be as close to the actual diameters as it is possible to measure in given situation.

DISCUSSION

These measurements are made upon abnormal cases and show, we think, though we have no normal cases to compare them with, a generalized and irregular diminution in caliber (Table I). This, of course, is to be expected in cases with such advanced sclerosis of the vessels as to cause gangrene. Injections, during life, of opaque substances (potassium iodide, etc.) into the blood vessels of extremities have been tried fairly successfully, but they are rather dangerous. Such a demonstration of the vascular bed before operation would be ideal for determining amputation level.

Inspection of the films of the injected arterial system in these cases shows such a widespread involvement of the arteries by the sclerotic process that amputation in the mid thigh was entirely justified. This was borne out by the dissections which disclosed extreme and widespread endarteritis. It is rather a common experience, especially in diabetics, to have local amputation for gangrene fail to heal. Subsequent higher amputations often remain unhealed until a mid thigh amputation is done. Of course, in extreme cases this will fail to heal also as the process is generalized.

It is rather easy to see why this is so. The blood vessels were probably supplying almost the minimum requirement for local metabolism under ordinary conditions. Any trauma, infection, etc., or other stimulant of repair brings about a reaction which can not be supported by the blood supply, so healing does not occur. The reaction often stirs up the endarteritis with the result that the circulation is shut off, and the gangrene extends upward. From the films and dissection of these seven cases with generalized arteriosclerosis and gangrene of an extremity, it is evident that amputation should always be performed high enough to reach large vessels, probably still giving a good blood supply and with a fairly rich bed of anastomoses. This conforms with the experience that mid thigh amputation gives the most satisfactory result if any is to be obtained in these extreme cases.

CONCLUSIONS

Inspection of X-ray films of the extremity in cases of arteriosclerotic gangrene does not often indicate by the calcification in the arteries the profound changes and the general involvement of the arterial system by the arteriosclerosis and endarteritis.

Inspection of films made of amputated legs in which the arterial system was injected with barium shows this general change clearly.

Measurements with calibrated rods of the inside caliber of six major arteries in the leg agree closely with those made upon X-ray films following injection of the arteries with barium and show this generalized and irregular decrease in size.

The future use of opaque media injected into peripheral vessels will make it possible to measure these vessels accurately and determine the extent of their disease. This opaque substance must be harmless, nonirritant to the vessel walls, and readily excreted from the body.

CLINICAL SURGERY

FROM THE SURGICAL CLINIC OF THE MELBOURNE HOSPITAL

OPERATIVE TREATMENT OF HYDATID CYSTS OF THE LIVER

HAROLD DEW, F.R.C.S., F.C.S.A., F.A.C.S., MELBOURNE, AUSTRALIA

ALTHOUGH hydatid disease is most commonly met with in Australia, New Zealand, and South America, sporadic cases occur in all parts of the world. In about 70 per cent of all cases, the liver is involved. The following distinct types of lesion are here found: (1) Simple univesicular cysts which are usually found in children or young adults. (2) Multivesicular cysts or cysts containing daughter cysts. These are often of a large size with an irregular, thickened adventitia, are often bile stained and typical of the disease in the adult. (3) Complicated cysts which are usually multivesicular, the common complications being rupture into the biliary channels, suppuration, or rupture into the abdominal or thoracic cavities.

PRE-OPERATIVE ROUTINE

In about 75 per cent of cases, the cyst occurs on or near the inferior surface of one of the hepatic lobes, a painless tumor being palpable in the upper part of the abdomen. The others occupy the subdiaphragmatic zones where they usually remain latent until they are of a large size, often manifesting themselves only by the onset of one of the already mentioned complications. It is, therefore, essential that a roentgenogram of the diaphragmatic area be taken in order to detect any distortion or elevation that may be present. Intrathoracic extension or the presence of an unsuspected pulmonary cyst may also be revealed. When it is remembered that more than one cyst is present in at least 60 per cent of cases, the importance of a preliminary roentgenogram is realized. In addition the Casoni intradermal test and the complement fixation reaction should be performed. Except for the intravenous exhibition of calcium chloride in those complicated cases with jaundice, no special pre-operative treatment is required.

THE OPERATION

Anæsthesia. As a rule there is no contra indication to general anæsthesia except in the rare cases of hepatobronchial fistula in which local anæsthesia with paravertebral nerve block is the method of choice. There seems to be no doubt that local anæsthesia carries with it some risk of anaphylactic shock, which, owing to the abolition of this peculiar state by general anæsthesia, is absent when ether is administered. If for any reason local anæsthesia is used, anaphylactic symptoms, if they occur, can be controlled by the intravenous injection of 5 minims of 1: 1000 adrenalin.

The incision. This should be made so as to give the most direct access to the cyst, the position of which has been ascertained by clinical and radiographic methods. As a rule, a vertical paramedian incision with splitting of the rectus muscle gives excellent access, but at times Kocher's subcostal incision is more suitable. For cysts of the superior quadrants of the liver, a transthoracic approach with rib resection is essential. Since in these cases it is all important to avoid, if possible, opening the pleural cavity, the incision should therefore be made as low down and as far forward as convenient. In some cases, however, owing to non-obliteration of the phrenicocostal angle, the pleural cavity is opened. Suture of the diaphragm to the thoracic parietes may be desirable, but this is difficult to carry out effectively and, owing to the loss of support when the subjacent cyst is evacuated, the sutures often pull through, thus producing a sucking wound with its attendant risks. In non-urgent cases, it is advisable to paint the serous surfaces with 5 per cent iodine and carry out tamponage with iodized gauze to cause the formation of adhesions. Two or three weeks later, incision and evacuation of the cyst can be carried out through these adhesions without risk of pleural soiling or pneumothorax.

Exploration. After the peritoneum has been opened wide, retraction should be practiced, there being many disadvantages in the lack of exposure obtained through the small incisions

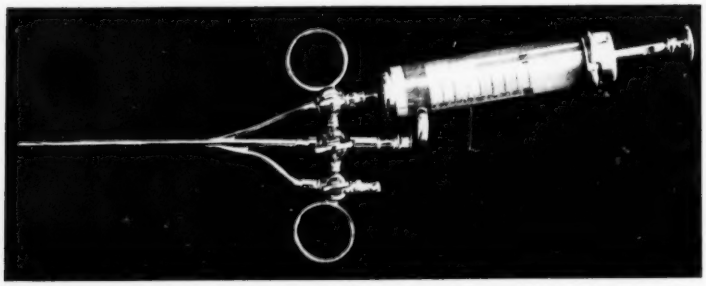

Fig. 1. Special two-way syringe which permits evacuation and injection of the hydatid cyst without removal of the needle.

sometimes advocated. It is important to bear in mind the frequency of multiple cysts and to palpate both lobes of the liver, the spleen, and the neighboring peritoneal folds. Neglect of this procedure has in the past been responsible for many errors in prognosis and for the onset of unforeseen complications at a later date. It is obvious that, in the case of transcostal operations, the extent of such exploration must be very limited. Peritoneal adhesions are rare in the case of univesicular but are common in multivesicular or in complicated cysts and may be welcomed by the surgeon as a help in protecting the peritoneal cavity from contamination.

Preparation of the field. As a rule only one cyst is dealt with at a time, although this depends on their size and relative position as well as on the condition of the patient. A warning must be given against attempting too much at one time.

The wound edge is carefully guarded by packs, and the stomach and intestines are packed off with a double layer of large flat packs so that the cyst wall lies well isolated in the wound. I use black packs for the superficial layer, because daughter cysts and scolices show up well against this background.

Evacuation of the cyst. The immediate risk in all operations on hydatid cysts is contamination of the operation fields with hydatid fluid, with hydatid elements in the form of brood capsules, scolices, or small daughter cysts, or with pus. Absorption of hydatid fluid when local anæs-

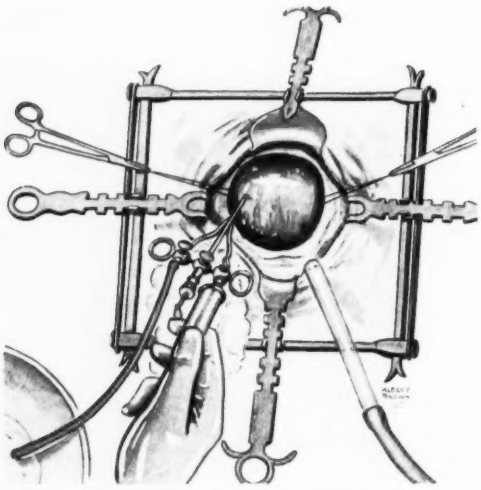

Fig. 2. The field of operation showing the special syringe used for partial evacuation and formalinization, guys of chromic gut inserted, and the tube of the pump in position.

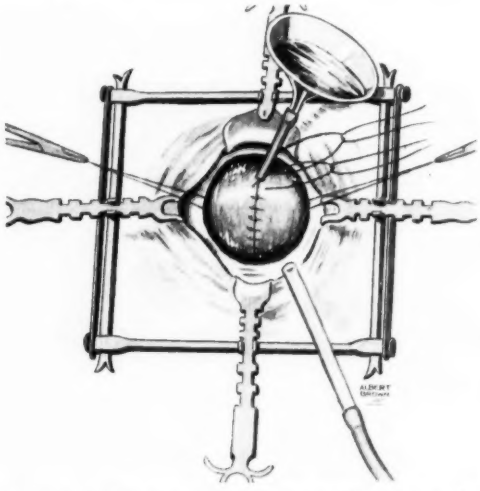

Fig. 3. Filling the evacuated cyst with saline under slight pressure. The last sutures are ready for tying. (One layer of packs has been omitted for the sake of clarity.)

thesia is used may give rise to severe or fatal anaphylaxis while the use of general anæsthesia may cause less severe, delayed, postoperative anaphylactic symptoms. It is therefore important to prevent contamination of the field with hydatid fluid, although it is often impossible to avoid it completely.

If active hydatid elements are shed into the operative field, they may become implanted in the peritoneum or parietes where they grow and give rise to secondary cysts, which manifest themselves only after some years of growth. Neglect to take definite precautions against such contamination was common in the past, so that as a result the older records contain many reports of cases of postoperative secondary cysts of the parietes and abdominal cavity.

In thick walled cysts it is sometimes possible by means of a fine curved atraumatic needle to insert guys of fine chromic gut so as to give the assistant control of the cyst. In thin walled cysts, this maneuver often causes puncture and collapse of the elastic laminated membrane of the parasite. As a result, the high intracystic pressure may force fluid or even scolices through the needle punctures with contamination of wound.

In any doubtful case the guys should be dispensed with until a later stage, the cyst being kept in the wound by the pressure of the assistant's hands on the abdomen below. The cyst should then be punctured with a large hollow needle and the fluid conveyed away from the operation field by tubing. I have found a special two-way needle and syringe of great value in this connection (Fig. 1).

The needle is inserted into the most accessible part of the cyst wall. As a rule this is covered by peritoneum only, but sometimes a layer of hepatic tissue must be traversed. Hydatid fluid escapes through a rubber tube into a dish. The character of the flow should be noted. In the case of a univesicular cyst a large quantity of fluid escapes in a continuous stream before the needle becomes blocked with the collapsing mother cyst. The block can readily be removed with a stylet. If daughter cysts are present, the flow lasts only a short time, that is, until the particular daughter cyst punctured is evacuated. If the needle is pushed further in, another small quantity may be obtained. The color and nature of the fluid also may give important information as to the state of the cyst contents. After as much fluid as is practicable has been run off, pure commercial formalin is injected from the previously charged syringe without removing the needle. Enough formalin should be injected to make, with the fluid remaining in the cyst, at least a 1.5 per cent solution. In the case of a cyst 10 centimeters in diameter, I inject 7.5 cubic centimeters, allowing the solution to act for at least 4 minutes in order that any free hydatid elements may be killed. During the delay, the packs should be rearranged, guys placed in the adventitia, and the large bore (15 millimeters) tube of the electric or water pump placed ready in lower angle of wound (Fig. 2).

The formalin can have little effect on intact daughter cysts, but it is worth while to use it, even when multivesicular cysts are present, in order to fix any scolices set free by puncture or manipulation. After the formalin has been allowed to act, the adventitia may be boldly opened, the assistant, either by means of the guys or by pressure on the abdomen below, keeping the cyst wall in contact with the packs. The wide bore tube connected with a water or electric pump is then used to evacuate any fluid or débris. With sufficient negative pressure, even large daughter cysts can be removed in this way, although in some cases the contents are so thick that the pump may prove ineffectual. In such cases, an ordinary tablespoon is very useful. Whatever method is adopted, complete evacuation of such cysts is often a time-consuming procedure. In the case of univesicular cysts the large, thick walled, mother cyst can usually be delivered intact, and by means of the pump all fluid can be readily removed, practically precluding any contamination of the area. Great care must be taken to evacuate all débris. Pouches and diverticula should be looked for and the inside of the adventitia either swabbed with dry gauze or irrigated with saline. After this, the cavity should be swabbed with 4 per cent formalin or 90 per cent alcohol, the excess being removed with dry gauze. No attempt should ever be made to remove the thick fibrous adventitia completely. Not only is this unnecessary, but owing to the intimate connection between the adventitia and the hepatic connective tissue and the frequent presence of large veins, such an ill-advised attempt is fraught with great danger and may be followed by a fatal result. In very large cysts partial removal of the extrahepatic portion of the adventitia may, however, be carried out to facilitate closure.

Treatment of the cavity. The ideal procedure is to close the cavity and the abdominal incision without drainage. However, this depends on the pathological state present:

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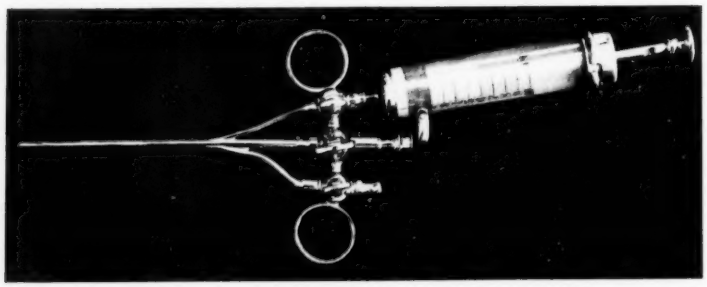

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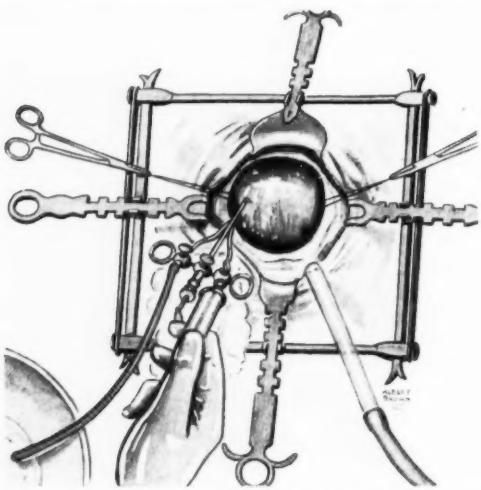

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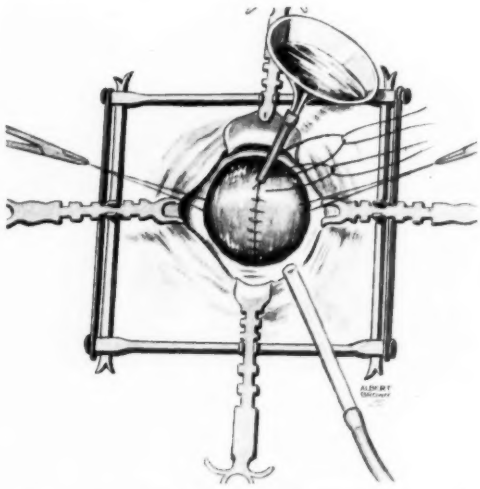

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Treatment of the cavity. The ideal procedure is to close the cavity and the abdominal incision without drainage. However, this depends on the pathological state present:

1. In the case of clean, simple cysts, when the inner wall of the adventitia is smooth and when

little if any bile enters, the cavity should be filled with sterile normal saline and closed without drainage (Fig. 3). The saline acts as a buffer against the entry of bile, obviates a postoperative pneumocyst, dilutes any bile that may leak in, and, as it is slowly absorbed, allows gradual contraction of the adventitious capsule. Provided asepsis is maintained, this method is followed by a rapid convalescence and leaves an intact abdominal wall.

2. If the cyst contains daughter cysts, it may often be safely treated in the same way, although owing to the difficulty of complete evacuation and the frequency of gross biliary leakage the method is not so universally applicable nor so safe. In any cases in which the surgeon is doubtful as to the completeness of evacuation or when bile enters freely, it is advisable (a) to leave one of the sutures in the adventitia long and to bring it out through the incision, (b) to place a drainage tube down to the suture line, or (c) to suture the adventitia lightly to the peritoneal suture line. These are safeguards against leakage into the peritoneal cavity and, if the pressure in the cavity rises because of infection, provide an efficient and safe guide to the sutured cyst in order to institute drainage.

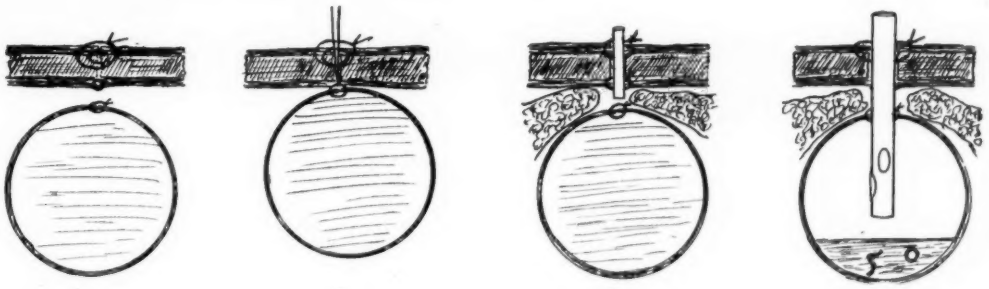
3. If the cyst is infected, a phenomenon which is usually associated with engorgement of the outer surfaces, deposit of recent lymph, omental adhesions, and turbid or foul smelling contents; or if the surgeon is uncertain as to the wisdom of closure for reasons such as difficulty of access, biliary contamination, multiloculation, etc., it is advisable to close the adventitia partially and provide drainage through a dependent part. The rubber drainage tube should have a wide bore, should be provided with lateral openings, and if possible the omentum should be brought into position around it. Such a method is essentially safe and although some successful cases of evacuation and closure without drainage of these types of cyst have been recorded, I believe that this procedure carries with it an unjustifiable risk. Hence, I advocate drainage in all such cases. In suppurative cases, it is obvious that if transthoracic drainage is undertaken, every effort should be made, by proper sitting of the incision or by means of a two stage operation, to prevent pleural contamination, an event which often leads to a pyopneumothorax.

4. Calcareous change in the adventitia of old standing cysts is not uncommon and presents some problems. This change is as a rule patchy, but in rare cases the whole adventitia may be converted into a thick, rigid, calcareous envelope. The parasite in such cases is usually dead and as such cysts are usually quiescent, operative interference is not often necessary. Operation should always be avoided if possible because of technical difficulties and because infection, if once introduced, invariably leads to the formation of a persistent sinus with a foul-smelling discharge. Sometimes, however, usually because of a low-grade infection, such cysts require operation. The operation should take the form of evacuation, treatment with alcohol, attempted suture of the adventitia, and closure of the parietal wound with a tube down to the suture line only. In this way it may be possible to avoid the introduction of infection or to control a quiescent infection without the distressing sequela of a chronic sinus. The methods of dealing with the cyst cavity are schematically shown in Figure 4.

Space will not permit any detailed consideration of the other types of complicated cyst. Each carries with it numerous problems of its own which I have discussed elsewhere (1). The outstanding principles of treatment of some of them, however, may be summarized as follows:

1. *Rupture of the cyst into the biliary passages.* Clinically, this complication is characterized by intermittent or persistent jaundice, biliary colic, hepatic tenderness, the passage of hydatid débris in the stools, and not infrequently by symptoms of suppurative cholangitis. As a result the diagnosis of complicated cholelithiasis is often made and exploration to this end carried out. When no gall stones are found, further search may reveal a hydatid cyst which should be dealt with by drainage. At the same time, the common bile duct should be carefully examined. If jaundice is present, it may be presumed that the duct contains hydatid débris or daughter cysts and that infection of the biliary passages is present. Drainage of the common duct should then be instituted.

2. *Rupture into the peritoneal cavity.* This may occur either spontaneously or following varying degrees of trauma. It is usually characterized by some degree of peritoneal shock, simulating other acute upper abdominal lesions, and is often accompanied by anaphylactic symptoms in the form of urticaria, erythema, dyspnœa, etc. It is obvious that, depending on the state of the cyst as regards infection, biliary contamination etc., there are many possible sequelæ. At operation, fluid and débris should be removed from the abdominal cavity as completely as possible, particular attention being given to the paracolic sulci and peritoneal fossæ. The under surfaces of



A. B. C. D.

Fig. 4. Schematic representation of the various methods of dealing with the cavity of a hepatic hydatid after evacuation. A, Filling with saline and closure without drainage. B, Filling with saline, closure, and suturing to peritoneum. One suture is brought out. C, Filling with saline, closure, and the placing of a drain down to the suture line. The omentum is in position. D, Open drainage. The omentum is in position.

the liver should be explored for the leaking cyst so that it may be evacuated and drained. It is of course probable that the patient will develop multiple secondary abdominal cysts some years later, and he should be warned of the necessity of keeping under observation at least 10 years.

3. *Rupture into the pleura or the bronchi* is a comparatively rare complication of subdiaphragmatic cysts, but many diverse pathological pictures are possible. Thus empyema, cholethorax, cholepyothorax, cholepyopneumothorax, or simple hepatobronchial fistula with bile stained expectoration may occur. Unless the surgeon is aware of the vagaries of hydatid disease in this situation, the true state of affairs may be realized only at operation. Such cases demand dependent drainage of the subdiaphragmatic cyst and this may sometimes be undertaken at the time of drainage of the commonly associated empyema or more frequently at a second operation.

POSTOPERATIVE COMPLICATIONS

1. *Anaphylactic symptoms.* Owing to the absorption of hydatid fluid at operation, there may be anaphylactic symptoms even after general anæsthesia, although they are usually delayed for some days. These take the form of vague pyrexia, dyspnœa, asthmatic attacks, cutaneous eruptions, etc., but as a rule are transient and of very little significance.

2. *Postoperative pyrexia.* If this is transitory, it is usually due to simple postoperative reaction or to anaphylactic effects. If it persists or reaches any height, it must be regarded as serious. In the case of cysts which have been closed, it often means the onset of infection in the cavity, probably from entry of infected bile or recrudescence of a quiescent infection. It may also be due to leakage through the suture line with resulting localized peritonitis. In all such cases, one should not hesitate to reopen the wound and to institute drainage.

Following the drainage of a suspicious hydatid, a high temperature usually means the onset of infection, the organism finding in the hydatid débris, which is often inadvertently left, an excellent pabulum for growth. In such cases, care must be taken that the tube is not blocked by membrane and that pus is not allowed to remain under tension. In suppurating cysts, drainage is usually free and in some cases a persistent high postoperative temperature with severe toxæmia is noted. Many of these infections are anaerobic. It would seem that open drainage brings about aerobic conditions which allow of rapid growth of streptococci. The latter are generally found exclusively in the discharge after a few days. The fact that the cyst wall and the wound of the soft tissues become infected with streptococci of a virulent type accounts for the severe toxæmia. Other causes of pyrexia are the onset of infective complications, as subphrenic abscess, localized peritoneal collections, empyema, extension into the hepatic tissues, or suppurative cholangitis.

3. Leakage into the peritoneal cavity through the suture line of a closed cyst is a well known postoperative complication and should be carefully watched for in all cases. It may give rise to a mild or severe localized peritonitis with pain, tenderness, rigidity, and toxæmia, and will necessitate re-operation and drainage. Occasionally, bile enters the peritoneum freely and a biliary effusion or choleperitoneum is produced. This may be latent and give rise to few symptoms but as a rule the presence of a low-grade infection causes suppuration and necessitates drainage.

4. Deep persistent jaundice accompanied by rigors and sweats may occur, especially with suppurating cysts or with cysts which have ruptured into the biliary passages. Such cases have an exceedingly grave prognosis, the institution of common-duct drainage being as a rule the only measure of value.

5. Intermittent drainage is sometimes a problem which may be due to the pocketing of a large cyst or the blocking of the tube by hydatid membrane or slough. We should guard against this by not shortening the tube too soon, by irrigation methods, and by careful exploration of the draining tract. In some cases, large sloughs derived from the avascular adventitia may separate with a profuse discharge. Such sloughs may be several square inches in area and their separation may be accompanied by secondary hæmorrhage, which is however rarely fatal. Persistent drainage over a period of months is not uncommon and may be due to a great variety of causes. Thus, the pocketing of discharge, due to irregular collapse of a large cyst, calcareous change in the adventitia, the formation of a thick, granulating cavity wall, the formation of soft calculi in the draining tract, or non-dependent drainage, may all be factors. In some cases the discharge is particularly foul and, owing to the persistence of toxic manifestations, further operation may be required. Sometimes profuse, persistent discharge of bile occurs. Although this usually ceases as contraction occurs, it is important to bear in mind that there may be another cyst causing pressure on the ducts or the ducts may be partially blocked by hydatid débris. In such cases the administration of ox bile by mouth is of benefit. In persistent cases a further operation to correct the condition must be done.

6. Secondary implantation cysts may occur in the peritoneum or in the abdominal wall. These cysts are derived from scolices or brood capsules which split at operation and manifest themselves at a period varying from 2 to 10 years after operation. In the past, the frequency of this complication has not been sufficiently recognized and until hydatid cysts are treated with the same respect as is an infected focus, they will continue to be relatively common. The methods of accurate protective packing, formalinization, and prevention of leakage already indicated are at the present time the best means at our disposal to obviate this complication.

7. Recrudescence of symptoms at a later date is sometimes due to the presence of a residual cyst. These may be readily overlooked at the primary operation unless careful exploration is carried out. Occasionally the relief of pressure occasioned by the evacuation of a superficially placed cyst allows a deeper cyst to extend forward and produces a swelling in the original site many months later. At other times the residual cyst becomes infected and somewhat puzzling symptoms appear at varying times after operation. It is in the detection of such cysts that I have found the complement fixation test elaborated by N. H. Fairley (2) invaluable.

8. Incisional hernia and intestinal obstruction from adhesions are rare postoperative sequelæ.

PROGNOSIS

In uncomplicated cysts, the results of the treatment which I have outlined are excellent, the mortality is negligible, and convalescence uneventful in the majority of cases. In complicated cases, particularly in the presence of suppuration, the mortality is higher and in nearly all cases is due to the spreading of the infective process. In suppurative cases the mortality approaches 20 per cent, while in intrapleural or intravisceral ruptures it is approximately 50 per cent. It is the frequency of complications—rupture, infection, or implantations—which often makes hydatid disease both as to morbidity and mortality so serious a surgical problem.

In determining whether a patient is cured or not we find the complement fixation test of great value. After complete evacuation of a single cyst the amount of complement fixed falls rapidly and if it persists to the extent of fixing 4 minimum hæmolytic doses of complement after 12 months, it is very probable that a residual cyst is present. The test should always be performed quantitatively and the serum tested regularly every 3 months after operation, if an accurate prognosis is desired.

CONCLUSION

In this short survey of the operative treatment of hepatic hydatids, it has been possible only to touch on some aspects of this interesting disease. Surgeons working in "hydatid" countries are constantly meeting with diverse clinical and pathological pictures, some of which tax their diagnostic powers and surgical ability to the full. If I have succeeded in throwing light on some of these problems, this article will have achieved its purpose.

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FROM UROLOGIC SERVICE, MICHAEL REESE HOSPITAL

A SIMPLIFIED TECHNIQUE FOR REMOVAL OF CALCULI IN THE PELVIC PORTION OF THE URETER

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THE removal of impacted ureteral calculi located between the point where the ureter crosses the iliac vessels and the point of entrance into the bladder, is often a very difficult procedure. This is due to a number of factors:

1. It is difficult to identify the ureter because it lies in most intimate relation to the peritoneum lining the iliac fossa and true pelvis. Unless the exposure be an adequate one, much valuable time is lost because of the retraction of the ureter inward with the peritoneum.

2. In some cases there is such a degree of infection of the periureteral sheath that rather dense adhesions to the iliac vessels and peritoneum have formed. We were obliged to expose the juxtavesical portion of the ureter intraperitoneally in one case in which an abdominal hysterectomy had been followed by the formation of such dense adhesions between the ureter, iliac vessels, and peritoneum, as to render mobilization of the pelvic ureter a hazardous procedure by the most commonly employed extraperitoneal route.

One should never attempt to separate forcibly an adherent ureter from the iliac vessels lest an uncontrollable hæmorrhage result from injury of some large arterial or venous trunk. Opening of the peritoneal cavity is unavoidable at times, especially in the female, during mobilizaton of the pelvic ureter. This has occurred in several of our cases, but the opening was immediately closed with fine chromic (No. oo) catgut.

In all operations on the pelvic ureter, the patient should be placed in extreme Trendelenburg position. No special preparation of the operative field is necessary. Some operators prefer a median incision for exposure of the pelvic portion of the ureter, while others employ a pararectal incision displacing the peritoneum toward the midline of the body so as to avoid opening the peritoneum. We prefer an incision which runs parallel to the outer half of Poupart's ligament and then continues almost vertically upward when it reaches the anterior superior spine of the ilium. The fibers of the external oblique aponeurosis are separated and then the internal oblique and transversalis muscles are divided as close to the outer border of the rectus muscle as possible. Upon reaching the peritoneum lining the iliac fossa, it is displaced inward with the aid of a gauze sponge until the iliac vessels are to be seen. The most difficult portion of the technique at this stage is the identification of the ureter. Since we have discontinued the pararectal or muscle splitting incision and have adopted the one giving a much wider exposure, we have been able to identify the ureter far more rapidly. Usually the ureter is retracted mesially by the assistant and easily overlooked. If one begins to look for the ureter proximal to the point at which it crosses the iliac vessels (Fig. 1), it is more readily identified than if one searches for it at a point in the true pelvis. As soon as the ureter has been identified, it is separated from the peritoneum lining the iliac vessels by a form of spreading dissection using blunt pointed curved scissors. As soon as the ureter has been completely separated in this manner, we place a temporary sling or loop of catgut around the entire ureter so that it can be drawn close to the more superficial portions of the operative field. We then proceed to insert a traction suture of fine catgut (No. oo) through the wall of the ureter just proximal to the point at which it crosses the iliac vessels (Fig. 1). An incision is then made with a very small scalpel (similar to those employed for eye operations) so as to open the lumen of the ureter.

The displacement inward of the peritoneum is now continued in a distal direction until the entire pelvic portion of the ureter is exposed (Fig. 2). An ordinary ureteral catheter is introduced in a distal direction through the opening previously made (Fig. 1) in the iliac portion of the ureter. This will yield valuable information as to the location of the impacted calculus and as to the degree of thickening of the ureteral wall opposite or below such an obstruction.

We do not propose to enter into a discussion as to whether calculi, especially those impacted in the pelvic portion of the ureter, are secondary to stricture formation here or whether the stricture is secondary to prolonged impaction of a calculus, i. e., is of decubital origin. It is our opinion that one is as common as the other and this must be borne in mind in the postoperative care after ureterotomy for calculi which it has been either impossible to deliver by non-operative methods

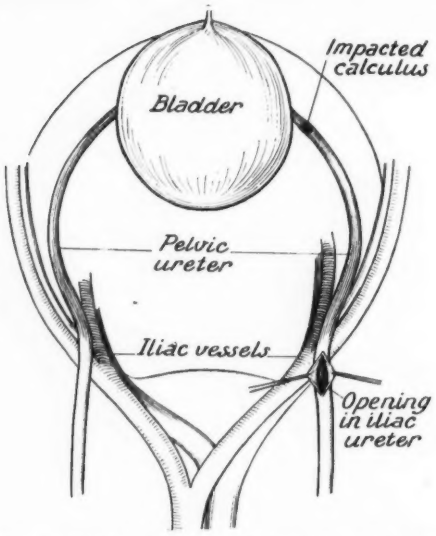

Fig. 1. Showing opening made between two traction sutures of fine (No. 00) catgut in the easily accessible iliac portion of the ureter proximal to the iliac vessels.

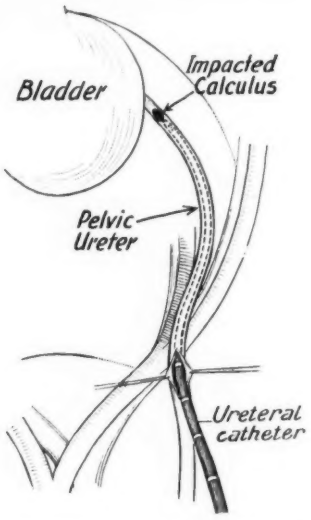

Fig. 2. Introduction of catheter through iliac ureterotomy incision to confirm level at which calculus blocks ureter.

or in which the presence of anuria and pyelonephritis served as indications for operative interference.

On account of the outward curve which the ureter follows after crossing the iliac vessels, it is very difficult in many cases to obtain adequate fixation of the ureter so as to incise directly over an impacted calculus. In order to obtain such fixation, it is desirable to convert the outward curve into a straight line. We have been able to do this by inserting a series of traction sutures similar to those employed in opening the ureter in its iliac portion as shown in Figure 1. The first set of these traction sutures is introduced about midway between the iliac vessels and the point where the ureter enters the bladder as shown in Figure 3. This fixes the juxtavesical portion of the ureter in such a manner that a second set of (Fig. 4) similarly inserted traction sutures of fine (size No. 00 or No. 000) catgut inserted just proximal or opposite to the impacted calculus enables the operator to make a small incision directly over the calculus under guidance of the eye. Such a small incision made in the long axis of the ureter is indispensable if one wishes to avoid a postoperative stricture, which often occurs if the ureter is opened by sense of touch alone. After removal of the calculus we pass a fair sized ureteral catheter (size 6) through the iliac ureterotomy incision (Fig. 1) in both a proximal (up to renal pelvis) and distal (into the bladder) direction. While this catheter is in place, the segment of ureter from which the calculus has been removed is carefully palpated in order to obtain information as to any decrease in its lumen or thickening of its wall indicative of stricture formation.

No attempt is made to close the incision in the pelvic ureter from which the calculus has been removed. A strip of drainage material known as Penrose wicking, i.e., a soft rubber drain made of the same material as used by dentists and called rubber dam, is placed opposite the opening in the pelvic ureter and allowed to come to the surface at the lower end of the abdominal incision.

A stiff, ordinary rubber tube should never be used in these cases because it may give rise to pressure necrosis of the iliac vessels with which it lies in contact. The iliac ureterotomy incision (Fig. 1) is closed with one or two interrupted sutures of fine chromic gut.

Care must be exercised not to enter the lumen of the ureter because of the danger that the chromic catgut may act as the nucleus of a future calculus. The soft rubber drain is left *in situ* for at least 10 days. Urine usually escapes for 5 or 6 days but this will cease promptly if no obstruction

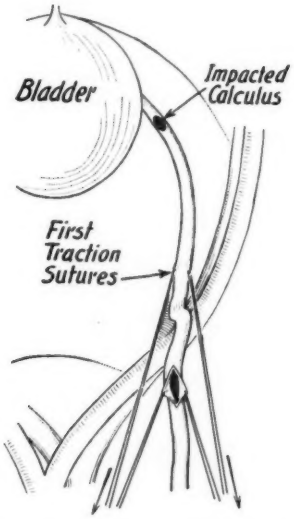

Fig. 3. First set of traction sutures inserted just below iliac vessels, through wall of pelvic portion of ureter. Note disappearance of outward curve of ureter.

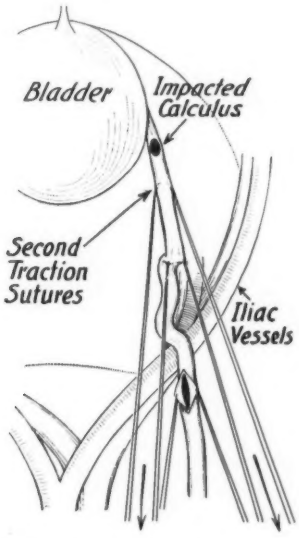

Fig. 4. A second more distally inserted set of traction sutures enables one to fix the ureter and corrects completely its outward curve. A third set of these temporary sutures at the level of the impacted calculus is rarely necessary. One can now make an incision directly over the calculus under guidance of the eye.

in the form of a stricture or overlooked calculus exists. The abdominal incision is closed layer by layer after a rubber drain has been inserted through its upper angle so as to drain any secretions which might collect in the iliac fossa.

The immediate complications following a ureterotomy in which the described technique is employed, are the same as those following any operation on the kidney or ureter.[1] One must be constantly on the lookout for reflex intestinal paresis (renal ileus), acute gastric dilatation, or anuria, if an obstructing calculus has been overlooked in the opposite ureter or kidney.

Of late complications, two deserve special mention, viz., stricture formation and urinary fistula. Every patient who has had a ureterotomy for impacted calculus should be examined as soon as feasible, for stricture. Dilatation should be done for such a narrowing at regular intervals, possibly once a month, in order to forestall the reformation of a calculus at the site of the stricture or proximal to it. Fistula formation is rare at present and is usually due to stricture formation or to an overlooked calculus which is located distal to the incision which had been made for the previous ureterotomy.

[1] Eisendrath, D. N. Postoperative complications in urology. Surg. Clin. N. Am. 1927, vii, 711.

A SIMPLIFIED TECHNIQUE FOR ABDOMINAL PANHYSTERECTOMY[1]

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COMPLETE removal of the uterus by the abdominal route according to any of the procedures hitherto described with which I am familiar has not always proved either an easy or wholly satisfactory operation, in my hands. Moreover, my observation of the work of a number of highly trained pelvic surgeons during the past 20 years, together with the verbal testimony of others, convinces me that I am not alone in this experience. I have witnessed one death on the operating table from uncontrollable hæmorrhage which occurred while an experienced gynecologist, possessing uncommon skill and mature surgical judgment, was performing an abdominal panhysterectomy by means of a widely practiced technique, for complicated pelvic disease. Repeatedly I have seen other men of merited renown as pelvic surgeons encounter annoyance and suffer embarrassment from obstinate venous bleeding which defied their resourcefulness during the execution of this operation. Occasionally, too, damage to the ureters has been observed. And, in one instance, it was my misfortune a few years ago to sustain a fatality from fulminating streptococcus peritonitis within 72 hours after an abdominal total extirpation of the uterus according to one of the best accredited plans.

Consequently, during the past 4 years I have been endeavoring to perfect a technique which would be relatively simple, easy of execution, and reduce to a minimum the three chief dangers, namely: (1) hæmorrhage, (2) infection, and (3) damage to the ureters. It is my belief that the operation presently to be described not only meets these major requirements but possesses in addition substantial minor advantages.

Since perfecting the operation, I have made a reasonably comprehensive, but not an exhaustive, survey of the literature, because I soon learned that an astonishingly large number of ingenious and meritorious modifications of standardized procedures have been described and it has not been possible for me to scrutinize all of them in detail. I have, however, examined a number of American, English, French, and German textbooks and systems, and have reviewed closely the procedures listed in various indices covering the earlier literature, as well as that of the past decade, without finding this plan described. If it later develops, however, that I have simply rediscovered a technique which has been previously described by another who antedated me in working along this line, I shall most willingly admit his priority of discovery, and herewith dedicate this publication to his memory and to the advocacy of what I believe to be a good operation based upon sound surgical principles.

Of historical interest in connection with the presentation of this new panhysterectomy technique is the fact that this happens to be the semicentennial anniversary of the first carefully planned total extirpation of the uterus by the abdominal route. On the 30th day of January, 1878, W. A. Freund first performed this operation for cancer of the uterus by a method which he had carefully worked out upon the cadaver. Moreover, in the doing of it he made use of the posture which later was perfected by, and is generally accredited to, Trendelenburg.

Three years later, in 1881, Bardenheuer, who was familiar with Freund's cancer operation, performed the first panhysterectomy by the abdominal route for a myomatous uterus.

In America, Dr. Mary A. Dixon Jones, on February 16, 1888, was the first to perform panhysterectomy for uterine fibroids. She first did an abdominal subtotal hysterectomy and then removed the cervix by way of the vagina.

In January, 1889, Dr. L. A. Stimson proposed and carried out his epoch-making contribution to hysterectomy, namely, preliminary ligation of the ovarian and uterine vessels.

The operation of panhysterectomy was further popularized in these early years of its history through the work of W. M. Polk, James Eastman, G. M. Edebohls, H. J. Boldt, and F. Krug in America; Trendelenburg, Schauta, Chrobak, and notably A. Martin in Germany; F. B. Jessett and Thomas Keith in Great Britain; and by Gouillaud, who was the first to perform it in France in 1891.

FOUR STANDARDIZED PLANS

Many ingenious and creditable modifications have been suggested from time to time since this early pioneer development of abdominal panhysterectomy until today at least four plans may be regarded as sufficiently well standardized and widely enough employed to be worthy of brief description. In all of these I shall omit that part

[1] A preliminary report of this operation appeared in the Journal of The American Medical Association 1928, xc, 596.

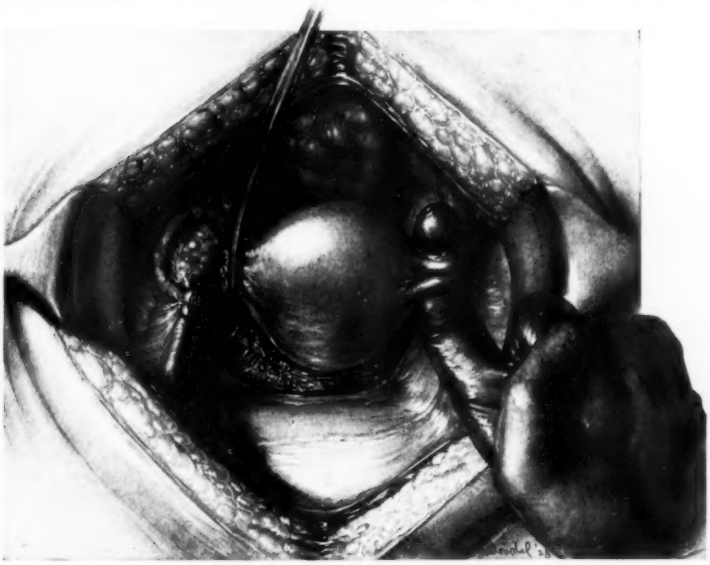

Fig. 1. A transverse crescentic incision has been made along the upper margin of the vesico-uterine peritoneum and continued on each side up to the uterine attachment of the round ligament. On the left, the index finger has perforated the broad ligament and is shown supporting the round ligament, the fallopian tube, and the utero-ovarian ligament. On the right, these structures have been divided and securely ligated by a transfixing ligature.

of the technique which deals with the appendages, since the variations employed in this part of the operation are irrelevant to the purposes of this communication.

Plan 1. The uterine appendages having been appropriately dealt with, the vesico-uterine peritoneum incised transversely, the bladder freed and pushed well down and the broad ligaments laid open to expose the uterine vessels, these are divided and ligated at the level of the internal os. Strong traction upward is now made upon the uterus while the operator, using sharp dissection applied close to the cervix, encircles it repeatedly, each time at a lower level, and divides all structures attached to it until the vaginal vault appears like the top of a tent. This is first opened at an advantageous point; ballooning occurs, and detachment is completed by a circular incision close to the cervix. An assistant follows the knife throughout the dissection, applying a hæmostat to each bleeding vessel and to the vaginal vault at strategic points as it is cut across. This procedure may be aptly described as the peeling-out operation.

A modification of this plan is to core or ream the cervix out, leaving a thin cylinder of cervical tissue to which the supporting basal ligaments are attached.

Plan 2. The preliminary steps dealing with the appendages having been carried out, the uterine vessels divided and ligated at the level of the internal os, and the bladder separated from the cervix and carried down sufficiently to expose the anterior vaginal wall, the operator now applies a stout clamp parallel and close to the cervix on either side, embracing in its bite the parametrial tissues and basal portions of the broad ligaments quite down to the vaginal vault. These tissues are now divided. The vagina is opened anteriorly, the cervix is grasped with a volsella and drawn forward into the pelvis, while its vaginal attachment is divided laterally and behind with curved scissors or a knife.

Plan 3. This is the Doyen operation. Without preliminary disposal of the appendages, the uterus is grasped with a heavy volsella and drawn strongly upward and forward over the symphysis. A blunt instrument is then introduced from below into the vagina, by an assistant, and carried well up into the posterior fornix. Cutting down upon this, the operator opens the posterior vaginal wall. Through this opening the cervix is grasped

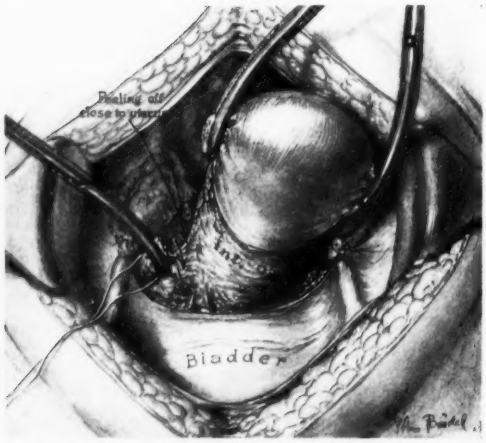

Fig. 2. The uterine vessels on the right side are shown clamped and divided with a ligature encircling them. The arrows indicate the direction in which blunt dissection is employed to strip these vascular trunks well away from the cervix down to the basal segment of the broad ligament. This step serves to drop the ureter well away from the danger zone.

Fig. 3. The bladder is here being gently freed from the cervix by means of blunt dissection applied to its relatively avascular central zone. It is to be particularly noted that the bladder usually separates, leaving the pubocervical (subvesical) fascia covering the cervix. It is in this structure that most of the venous plexus is contained. Step 2 of the technique of the operation describes the method of utilizing this anatomical fact to advantage.

and drawn into the cul-de-sac. Its vaginal attachment is then divided laterally and anteriorly, which permits it to be drawn sharply backward and upward. The bladder is separated from below as it comes into view, and the uterine vessels and appendages are dealt with in sequence as they are approached.

Plan 4. One other plan, with various minor modifications, deserves special mention for two reasons: first, because it is championed by a number of excellent pelvic surgeons and, undoubtedly, is a better operation than any one of the three already mentioned; and second, because the original was devised by an American, Dr. J. F. Baldwin,[1] of Columbus, Ohio, and a description of the technique published in 1916. It differs essentially from the three plans outlined above in the fact that after the initial opening into the vagina is made the index finger or a strong hook is introduced to serve as a guide and aid in completing the cervical detachment. Quite different also is the Baldwin method of suturing the round ligaments into the angles of the vagina and of closing the latter by a purse-string suture, which further serves to invert its cut margin.

DEVELOPMENT OF AUTHOR'S TECHNIQUE

It cannot be denied that each of these plans, as well as a great many similar procedures that may justly be considered minor modifications of these type operations, possesses distinctive merit. Nor can it be justly contended that the vast majority of total hysterectomies cannot be comfortably and satisfactorily executed by one of these established methods. But we are less interested today in the large percentage of successes that can be legitimately credited to the end-results of an operative procedure than we are in the smaller number of technical difficulties, complications, and failures that persistently crop up to mar our records. Such deficiencies in no inconsiderable number are to be found recorded in every tabulated statistical study of the end-results of abdominal panhysterectomy that I have reviewed. It is highly improbable, therefore, that any experienced pelvic surgeon will deny that, by any technique now in vogue, occasionally he finds this operation difficult of execution; that hæmorrhage is frequently troublesome, and occasionally embarrassing, even to the extent of jeopardizing one or both ureters in the urgent necessity of its immediate control; that

[1] Am. J. Obst., 1917, lxxv, 263; Tr. Ass. Obst. & Gyn., 1916, 1917, xxix, 280.

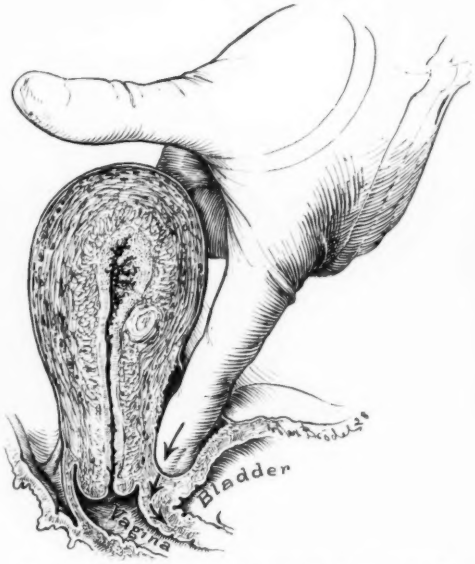

Fig. 4. A sagittal view with arrows indicating the direction and depth of the bladder dissection well below the level of the external os uteri. When the bladder is dropped well down the ureters are carried still further from the danger zone.

Fig. 5. The uterus is here shown lifted well upward and forward over the pubis. A transverse incision has been made through its posterior peritoneum 1 centimeter above the attachment of the uterosacral ligaments. The index finger is depicted applying blunt dissection to the relatively avascular midsection of the cervix and upper vagina for the purpose of separating the rectum well below the level of the external os uteri.

measures to combat or prevent postoperative shock are now and again required; that actual damage to ureters still occurs; and that, in rare instances, a fulminating streptococcus peritonitis brings a rapid exodus to his patient and profound mortification to himself. Such, at least, are my own convictions, which are based not only upon personal experiences but also upon the observations and testimony of a number of exceptionally competent gynecologists with whom it has been my privilege either to be associated or intimately acquainted during the past 20 years.

Consequently I have given much thought to the development of a simplified technique for abdominal panhysterectomy which could reasonably be expected to reduce to a minimum these irritating and disastrous occurrences, with the result that the operation now to be described has been gradually evolved. Five features of it were specifically designed to achieve this end, namely:

1. Complete separation of the cervix posteriorly, as well as anteriorly, below the level of the external os by means of blunt dissection applied according to a carefully devised anatomical plan and confined to its relatively avascular mid-section. The specific purpose here is not only separation of the bladder and rectum but, particularly, segregation of the loosely attached, fan-shaped lateral plexus of veins on each side into a narrow zone adjacent to the basal portion of the broad ligament in front and behind, so that they may be included in a single clamp to be applied to the latter prior to its detachment. By this simple device the free bleeding usually encountered in the lower lateral cervical region, which requires the application of multiple hæmostats and sutures uncomfortably close to the ureters, is completely avoided.

2. Detachment of the divided and ligated uterine vessels from the lateral margins of the cervix down to the basal portions of the broad ligaments, in addition to detachment of the bladder and pubo-cervical fascia anteriorly, in order to drop the ureters considerably farther away, where they are practically safe from mechanical injury.

3. The possibility of a postoperative streptococcus peritonitis from the cervix is reduced to a

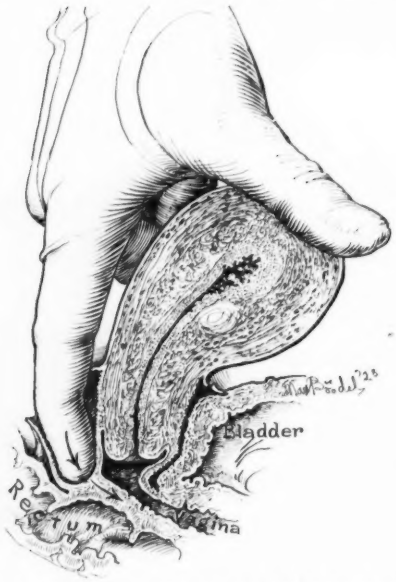

Fig. 6. A sagittal view showing the bladder dissection completed with arrows indicating the depth and direction of the rectal dissection.

minimum, not only through preliminary surgical toilet of the vagina and cervix, but also by reason of the fact that at no stage of the operation is the cervix squeezed by the application of forceps to it; nor is it at any time drawn into the pelvic cavity; nor is either a finger or hook introduced into the vagina adjacent to the cervix to serve as a guide in detaching it. Only the knife enters the vagina, and this is discarded as soon as the vaginal detachment is completed.

4. By means of a specially devised angle suture the severed basal segments of the broad ligaments and the uterosacral ligaments are firmly anchored to the lateral angles of the vaginal vault in such a way as to guarantee its adequate support. The usual round ligament attachment to the vaginal vault is, of course, also utilized.

5. The complete absence of hæmorrhage, which is accomplished without the application of multiple clamps and sutures, greatly simplifies the technique and permits perfect exposure of the field at every step, so that an accurate anatomical dissection is carried out with ease and rapidity and without fear of damage to the ureters. The time required for completion of the operation is, therefore, substantially reduced and the danger of surgical shock is eliminated.

Technique of the Operation. 1. The bladder and rectum should be empty. Preliminary, thorough surgical toilet of the vulva, vagina, and cervix is first carried out. In addition, the entire vagina, vaginal portion of the cervix, and, particularly, the external os and cervical canal are thoroughly treated with the official tincture of iodine, 20 per cent mercurochrome, or Scott's solution. The external os is then tightly closed by aseptic suture and a dry sterile gauze pack is introduced into the vagina, one end of which is left outside to which a clamp is attached, so that it can be readily withdrawn just before the vagina is opened above. The usual surgical toilet of the abdominal wall is then made and the sterile draperies are properly arranged.

2. A lower midline incision is made from the symphysis pubis to the umbilicus.

3. Adequate exposure of the pelvis is secured through use of the Trendelenburg posture, together with the judicious use of wet gauze packs.

4. The body of the uterus is now grasped firmly with an appropriate instrument and lifted well up, provided only that its pathology is known to be benign in character.

If, however, malignancy has been demonstrated or is suspected, the operation must be modified to include removal of both tubes and ovaries, and it is particularly stressed that no compression whatever should be applied to the uterus, either by instruments or by the surgeon's hands, until its extrinsic blood and lymphatic channels have been absolutely blocked by ligation and division of its four cardinal circulatory trunk systems, namely, the two ovarian and the two uterine. This I believe to be a sound and effective precaution against the possible dissemination of malignant cells by squeezing them out into adjacent vascular currents.

5. A transverse, crescent-shaped incision is now made through the vesico-uterine peritoneum at the upper margin of its loose attachment to the uterus and is carried laterally on each side to the uterine attachment of the round ligaments.

6. Into the angle of this incision on each side the index finger is introduced and burrowed bluntly through the loose areolar tissue of the upper portion of the broad ligament, perforating its posterior layer close to the uterus and below the level of attachment of the round ligament, the fallopian tube, and the utero-ovarian ligament.

7. This aperture is bluntly enlarged sufficiently to permit the approximation of these three structures to form a single pedicle, to which two stout clamps are applied, and amputation is done between them close to the uterus.

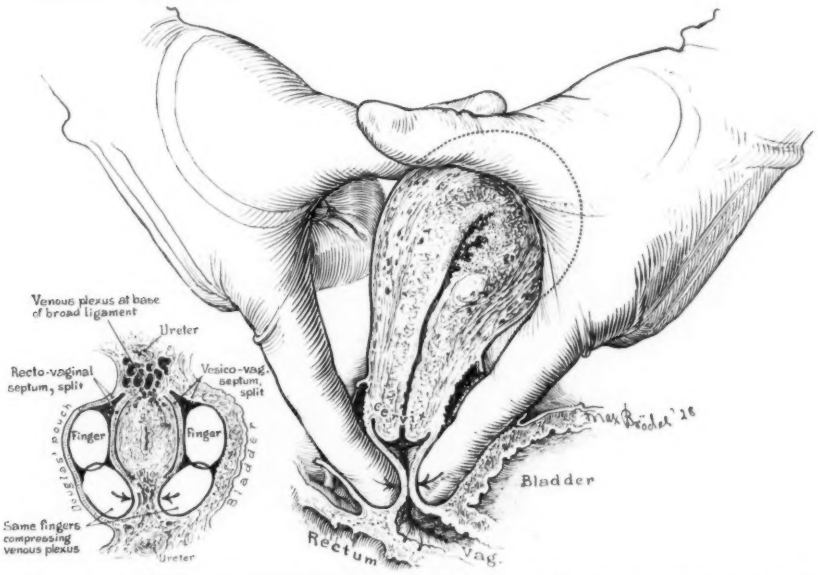

Fig. 7. A sagittal view showing the test being applied to determine that the anterior and posterior dissections have been carried down to the proper level. The inset depicts the method of segregating the vascular plexus on each side into a narrow zone adjacent to the basal segment of the broad ligament.

8. Transfixing ligatures replace the two clamps on the severed appendage stump, while the two applied to the cornua of the uterus are henceforth used as tractors. The original instrument with which the body of the uterus was grasped for the purpose of elevating it is now removed.

9. Traction upward upon the uterus now brings clearly into view the skeletonized uterine vessels, which are clamped and divided on each side at the level of the internal os. Ligatures replace the clamps on these vessels, care being exercised not to include any cervical tissue in passing the needle.

10. The severed uterine vessels, with ease and safety, may now be bluntly dissected away from the cervix down to the point of their emergence above the thick basal segment of the broad ligament on each side.

11. The uterus is drawn strongly upward and the bladder is easily separated by blunt dissection with the gauze covered index finger first from the cervix and then from the anterior vaginal wall well down below the level of the external os. In most instances the line of cleavage along the course of least resistance here is between the bladder and the pubocervical (subvesical) layer of fascia, so that, after the bladder has been pushed well down, close inspection of the cervix anteriorly will disclose that it is covered with a thin but definite layer of fascia. It is in this fascia that the troublesome vascular plexus is contained. If now a T-shaped incision be made through the fascia with the transverse cut a little below the level of the internal os and the vertical one over the middle of the cervix, the fascia layer together with the vessels may be easily freed from the cervix with the index finger and pushed laterally on each side, so that the vessels are nicely segregated adjacent to the basal segments of the broad ligaments.

Steps 10 and 11 serve further to drop the ureters well away from the cervix where damage to them is scarcely possible, if reasonable care is exercised in the subsequent application of clamps and sutures.

12. Strong traction upward and forward is exerted upon the uterus, and a transverse incision is made through its posterior peritoneal reflection 1 centimeter above the level of attachment of the two uterosacral ligaments. The lower peritoneal flap resulting is quite firmly attached to the posterior wall of the cervix, and sharp dissection vertically downward for at least 2 centimeters is necessary in order to free it sufficiently to permit introduction of the left index finger. Below this

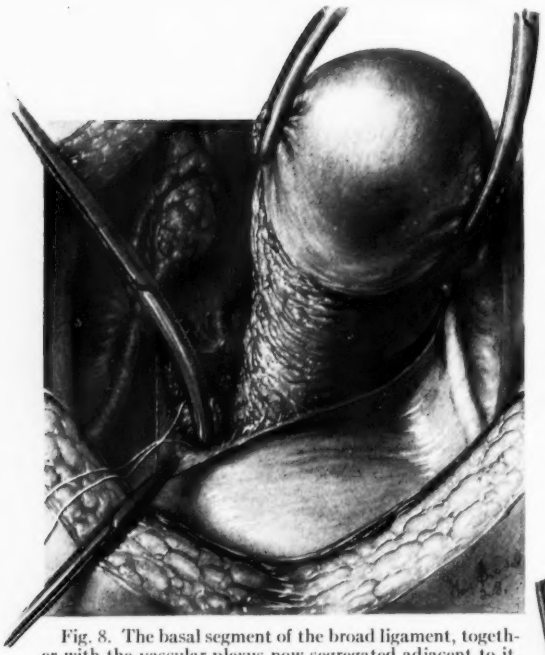

Fig. 8. The basal segment of the broad ligament, together with the vascular plexus now segregated adjacent to it, is here shown clamped and divided, with a ligature encircling it.

level the peritoneal and rectal attachment is quite loose and blunt dissection is now utilized, first to free the peritoneum from the cervix, and then is continued downward to release the rectum from the vagina below the level of the external os. Bleeding does not occur in this step of the operation, if care is exercised not to carry the dissection laterally on either side into the broad ligament zone.

13. If the uterus now be lifted well up, the two index fingers may readily be apposed below the level of the vaginal portion of the cervix by invagination of the anterior and posterior vaginal walls respectively, thus demonstrating that the bladder and rectum have been freed from the vagina sufficiently low down.

14. The two uterosacral ligaments are now clamped, divided, and ligated close to their cervical attachments.

15. The dense basal segment of the broad ligament on each side, together with the vascular plexus adjacent to it, which has been segregated through the earlier blunt dissection carried out over the central zone of the cervix in front and behind, may now be easily grasped close to the lateral border of the cervix, divided, and securely ligated, the clamps being removed. If the cervix is elongated, this step has to be repeated at a lower level.

16. The vaginal vault now comes up into plain view on all sides and the sterile gauze vaginal pack is withdrawn from below. Note that even at this stage of the operation there are no clamps in the pelvis and that no troublesome hæmorrhage has been encountered. The anterior vaginal wall is incised, the vagina promptly balloons, and the incision is extended around the cervix, four clamps being applied to the vaginal vault as it proceeds; one anteriorly in the midline, one laterally to each angle and one posteriorly in the midline, as the entire uterus is lifted out of the pelvis, without the cervix at any time having come in contact with any intrapelvic tissue.

17. Special angle sutures now replace the two angle clamps as follows: the needle is first passed through the anterior vaginal wall into the lumen of the vagina 1 centimeter mesial to the angle clamp, it now twice transfixes the stump of the

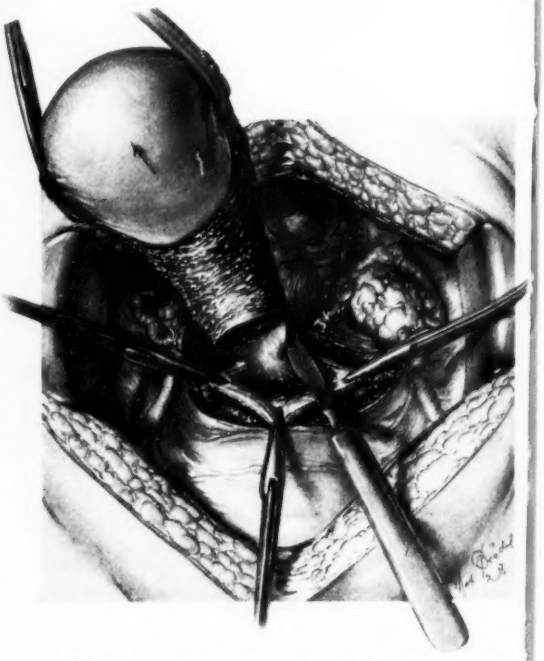

Fig. 9. The uterus has been completely detached and the amputation across the vaginal vault is being completed. Note that the cervix is not being squeezed by any compressing instrument and that it does not come in contact with the field of operation.

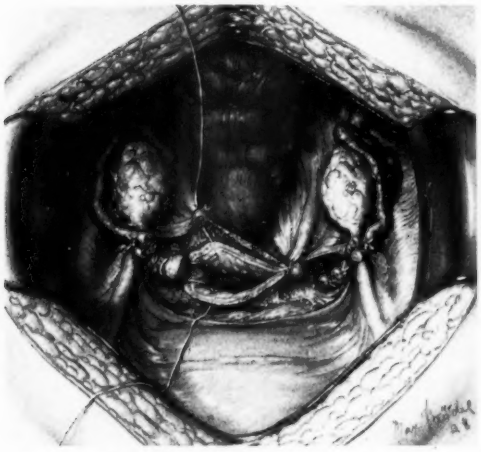

Fig. 10. The angle stitch is here shown. On the right it can be seen in detail. Note that it is first passed through the anterior vaginal wall 1 centimeter from the angle; it then twice transfixes the basal segment of the broad ligament, placing within this important structure a liberal mattress loop; it then continues through the posterior vaginal wall 1 centimeter from the angle and is finally made to transfix the stump of the uterosacral ligament. On the left the suture has been tied, snugly, closing the vaginal angle and approximating to it the two important supporting ligaments.

basal portion of the broad ligament, forming within it a liberal mattress suture loop; from here the needle again enters the lumen of the vagina, piercing its posterior wall also 1 centimeter mesial to the angle clamp and, further, is made to transfix the stump of the uterosacral ligament. When tied, this suture closes the lateral vaginal angle and snugly apposes to it for support both the strong basal segment of the broad ligament and the uterosacral ligament.

18. Further complete or partial apposition of the anterior to the posterior vaginal wall by suture, depending on whether or not drainage is to be employed, is now quickly executed.

19. A single mattress suture on each side now first engages the closed vaginal vault anteriorly and mesially to the angle suture, transfixes the stumps of the round and utero-ovarian ligaments and passes back to engage the posterior vaginal wall opposite the point of entrance. When tied, this suture snugly apposes the round and utero-ovarian ligaments to the vaginal vault, thus affording additional support to the latter and neatly suspending the ovaries.

20. The cut margin of the vesico-uterine peritoneum is now neatly sewed to the free edge of the

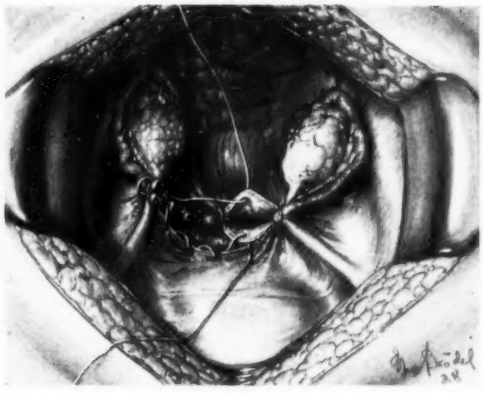

Fig. 11. The method of further closing in the vaginal vault and of suturing it both to the round and utero-ovarian ligaments is here shown.

posterior peritoneal flap, so that the pelvis is completely peritonealized with the vaginal vault and the ovaries strongly supported.

Modification A. If for any reason unilateral or bilateral salpingo-oophorectomy is indicated, the technique described becomes even simpler and is readily modified according to well established procedure to meet this requirement.

Modification B. If exposure of the cervix for the lower dissection is rendered difficult by reason of a benign pathological condition in the corpus uteri, such as enlargement from a myomatous change, it is recommended that a subtotal hysterectomy at or above the level of the internal os first be done. The cervix may then be easily and speedily removed by means of the technique as described.

SUMMARY

The perfected technique of this operation has been gradually developed during the past 4 years, in which period I have used it a number of times for various types of uterine disease. Thus far I have had no mortality and no postoperative complications, other than the minor ones uniformly associated with any major abdominal procedure. The operation is, therefore, now offered not with the optimistic fancy that no untoward results will later be chargeable to it, but with the confident belief that it possesses the following distinct advantages.

1. Each step of the operation is anatomically and surgically sound in principle.

2. It is relatively simple, easy of execution and consumes substantially less time than has been hitherto required by most operators for abdominal panhysterectomy.

3. There is complete freedom from hæmorrhage or troublesome oozing throughout, which is accomplished by means of a carefully planned anatomical dissection that serves to segregate the vascular network surrounding the lower cervix, so that not more than four hæmostatic clamps are required in the pelvis at any stage of the operation.

4. The danger of injury to the ureters is reduced to a negligible factor.

5. The accurate identification and preservation of the substantial basal portions of the broad ligaments and of the uterosacral ligaments for later coaptation to the vaginal vault by a specially devised suture affords an efficient guarantee against later prolapse.

6. The possible contamination of the field of operation or of the peritoneal cavity from the cervix harboring virulent organisms is reduced to a minimum.

7. The special step recommended in the cases in which malignant disease is suspected (step 4) constitutes an additional protection against possible recurrence. This is a factor of unquestionable merit.

8. Finally the factors which commonly produce shock and prompt exodus following panhysterectomy, such as excessive loss of blood, extensive mechanical insult to the tissues and prolonged operative manipulations, are completely eliminated through this simplified technique.

THE RÔLE OF POSTURE IN OBSTETRICS

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NOTWITHSTANDING the present-day excellent training of physicians in obstetrics, both general practitioners and obstetricians are only too likely to overlook the usefulness of postural treatment for difficulties of labor. Whenever delay in the progress of the child is encountered or some complication intervenes, one's first thought is apt to be of surgical interference. Yet in many cases, simple postural treatment will terminate labor without the necessity of resorting to instruments.

King (8) in 1909, writing on posture in obstetrics, said: "My chief contention is that the recumbent posture during labor is much overdone; that it is oftener persisted in either by custom or by the direct order of the obstetrician when it does positive harm by prolonging labor, by exhausting the woman, sometimes leading to the persistence of faulty presentations, as well as increasing the duration and intensity of the woman's suffering."

King noted that, in the recumbent posture, the woman is deprived of one of the chief factors by which the child is expelled; that is, the factor of thigh pressure on the walls of the abdomen and uterus, which is effective in a sitting, kneeling, or squatting posture. The squatting posture, he maintains, is a means of preventing transverse presentations or correcting them if they occur. In squatting, one foot is usually placed in front of the other, so that both thighs do not press equally on the surface of the abdomen and the direction of the pressure is not the same on both sides. When the squatting posture is used in a shoulder or arm presentation, the foot on the side toward which the child's breech is directed should be placed forward. This thigh then will come in contact with the back of the child and lift it and the breech end up toward the median line. The other foot is posterior to this one and rests on the toes. The thigh comes in contact with the projecting head of the child and levers it off from the iliac fossa inward toward the median line and into the pelvic brim, thus producing a head presentation. If the posture of "unsymmetrical kneeling" is adopted, instead of squatting, the woman puts one foot flat on the ground and kneels on the other knee (Fig. 1). In this case the foot flat on the ground must be on the side toward which the breech of the child is directed. In either case the woman should remain in the posture long enough to have a few labor pains, which aid in straightening the uterus and lifting the breech toward the median line. In neglected cases in which the woman has become too much exhausted to assume the squatting or kneeling posture, we may obtain thigh pressure by grasping the legs and bringing thighs in contact with the abdomen.

King advocates the squatting or kneeling posture not only for breech presentations but also for prolonged labor in which forceps would otherwise be indicated, as this posture hastens delivery. He advises that forceps never be applied in patients in whom the pelvis is normal until the effect of the squatting or kneeling posture has been tried. In cases of delayed rotation, he suggests the trial of a kneeling posture, with the woman kneeling on both knees and leaning backward on her folded limbs so that the pelvis comes in contact with her heels. In normal women the length of the leg is such that in this position the protuberance of the heel presses upon the great sacrosciatic foramen so as to push the forehead of the child into the hollow of the sacrum on one side and cause the occiput at the opposite acetabulum to go to the symphysis pubis.

De Lee (1) writes that in cases of contracted pelvis the patient may be placed in the Walcher position at the end of the first and the beginning of the second stage. Since the softening of the pelvic joints in pregnancy permits the sacrum to become movable, he states that we may rotate the innominate bones downward so as to enlarge the inlet by dropping the legs over the edge of the table on which the sacrum is fixed. Conversely, this motion narrows the outlet by causing the lower ends of the innominate bones to approach each other by reason of the oblique direction of the articular processes of the sacrum.

Among the aborigines, posture was an important means of treating difficulties of labor. The Indian women adopted a crouching position with one knee flexed completely and on the ground and the other one raised. The rationale of this position can be readily understood. If the fetal head is displaced into one of the iliac fossæ, it may be forced back over the inlet if the knee on the side of the displacement is raised.

Fig. 1. Crouching position with the knee on the side of displacement raised to force the presenting part over the inlet; the other knee is flexed completely and on the floor.

This squatting position may be used to advantage in cases of pendulous abdomen, because the abdominal wall rests on the thighs and the latter force the uterus into the proper position. It has been used in China since ancient times. Hartmann (6) notes that it is now used for labor and maintained for some days afterward with the aid of pillows and rolls of bedding. The maintenance of the squatting posture, according to Chinese custom appears to favor separation of the placenta and involution of the uterus.

In cases of pendulous abdomen, an abdominal binder snugly applied while the patient is in the dorsal recumbent position renders the squatting position more effective. It reposits the uterus and directs its axis in the same direction as that of the pelvis. Without this assistance the force of the uterus in cases of pendulous abdomen is frequently misdirected; that is, the child is directed backward against the spine instead of along the axis of the pelvis.

The following case illustrates the value of the squatting position in cases of pendulous abdomen.

Mrs. J. J., aged 30, iv-para (all difficult labors), was admitted to the Sydenham Hospital April 14, 1928. She had a pendulous abdomen. She had been in active labor since 8 p.m. on April 12, but there was no progress. Although the cervix was fully dilated, the head was not engaged and the patient was exhausted. A binder was applied and morphine and magnesium sulphate administered subcutaneously. After sleeping for two hours, she took the squatting position in bed, with her back resting against the wall. Her thighs were flexed to an exaggerated degree and the abdomen was allowed to rest on the thighs. The head engaged, the pains became effectual, and a child weighing 10 pounds, 14½ ounces was soon delivered.

Lichtenstein (9, 10) advises that, after the child is delivered, the patient be placed in a squatting position with the knees and hips flexed. She should grasp the thighs near the knee joint to hold this position comfortably. The position should be maintained until the placenta is completely separated, and again for about three-quarters of an hour after the delivery of the placenta. The woman is not moved from the bed, but the head of the bed or mattress is raised and two or three cushions are laid against it, on which the patient squats. Lichtenstein maintains that this position insures complete separation of the placenta with the minimum of bleeding and prevents atony of the uterus. In 60 of Heusler's (7) cases the squatting position was used and it was found that it did not diminish bleeding or have any other advantage over the usual method of obtaining separation and delivery of the placenta. Steinmetz (18) observed among the Indian tribes that Tonkawa women maintain the squatting posture until after expulsion of the child.

In women with a slightly contracted anteroposterior diameter of the inlet or with a normal inlet but slightly overgrown child, the anteroposterior diameter of the inlet can be increased from 0.5 to 1.0 centimeters by the use of the Walcher position (Fig. 5). This position frequently enables one to obtain a normal delivery in cases in which the use of instruments would otherwise be necessary. Even if it does not avoid the necessity of instrumental delivery, it may make a simpler form of interference permissible; for example, a low forceps instead of a high forceps operation. Even in medieval Italy a posture similar to the Walcher position was used when fat women were to be delivered (Fig. 4).

In 1898 Dickinson (2) discussed the use of a combination of two operating positions in obstetrics in the presence of certain complications; namely, the Walcher and the Trendelenburg. In deliveries in hospitals, where an operating table is available, the patient is placed on the Trendelenburg incline and slid upward until she balances on the sacrum, the legs hanging over. In a private house, the posture is easily improvised by using a

chair without rungs between its back legs. The chair is placed on its face across the foot of the bed, the back forming the inclined plane for the Trendelenburg position. The patient is prevented from slipping by means of a sheet passing over the shoulders and behind the neck. The ends of the sheet are tied to each rear leg of the chair. The buttocks project beyond the back of the seat. The legs are swung outward until the thighs hang outside the upturned chair legs. The weight of the lower limbs causes them to drop toward the floor, the knee lying lower than the hip. With this position the vulva is at a convenient height for the operator and the direction of the canal formed by the vagina and cervix into the uterine cavity is more direct and more nearly level than in any other posture. Moreover, the brim of the pelvis is enlarged to its greatest anteroposterior diameter by the Walcher position. This posture may be used for version; prolapse of the cord; high manual rotation of an occipitoposterior to an occipito-anterior position; flexion of a brow presentation; correction of a face presentation especially if the chin is to the rear; or in laparotomies when free access to the vagina is desirable, as in cases of ruptured uterus or cæsarean section. For ordinary delivery under anæsthesia, after the head has passed the brim, the dorsal posture with the thighs strongly flexed against the abdomen is considered by Dickinson to be the best position, as it measurably straightens the birth canal. This is also an excellent position for operations on the perineum and cervix.

Samuel (15, 16) has found that in normal labor, as well as for various abnormal presentations other than transverse, and when the pelvic outlet is slightly narrow the following procedure during the second stage of labor is useful: The patient is instructed first to flex the legs; then to rotate them outward; and finally, grasping the underside of the knee joint, to flex the thighs strongly against the abdomen. In this way the pelvic outlet is widened and the pain of labor reduced; also, the woman can use her own muscles to better advantage. When the head is sufficiently advanced so that a comfortable segment of it is visible and it is evident it must soon pass the perineum, the patient may be turned on her left side; but she should still keep her right leg flexed while the head is delivered, so as to protect the perineum. For transverse presentations, Samuel prefers the squatting position described by King. The Walcher position, he says, sometimes makes normal delivery possible with moderate narrowing of the pelvis, or makes it possible to substitute a simple for a more complicated operation.

Fig. 2. Squatting position. The thighs are flexed to an exaggerated degree, the abdomen resting on the thighs. The patient supports herself by hanging at the foot of the bed. The same position may be maintained by squatting on a cushion with the back against the wall and grasping the knees.

In the occipitoposterior position, when the head is at the brim, the placing of the patient on the side toward which the fetal back points helps the child's legs to fall forward, assists flexion, favors rotation of the back forward, and may secure engagement in the anterior position.

An objection frequently raised against the use of the Walcher position is that it causes discomfort. Since the position must be maintained for some time to be effective, it is essential to make the patient as comfortable as possible during its use. For example, if the feet are supported, the Walcher position may be maintained for 45 minutes; whereas without this support it can be held for only 5 minutes or 10 minutes at the most. To allow the comfortable and sustained use of the Walcher position, I have designed an obstetric table equipped with a shelf on a sliding rack that can be adjusted exactly to fit the height of the patient. For home deliveries, one can improvise a comfortable way of maintaining the Walcher position by having the patient place her feet on a foot-stool or cushion.

Simms (17) states that the obstetric chair was in use for many centuries, but in recent times "seems to have fallen into complete desuetude." He quotes a description of the obstetric chair from the first book of Soranus, of Ephesus, on the diseases of women, as follows:

Fig. 3. Squatting position of the Tonkawas (after George J. Engelmann, *Labor among Primitive Peoples*. J. H. Chambers & Co.).

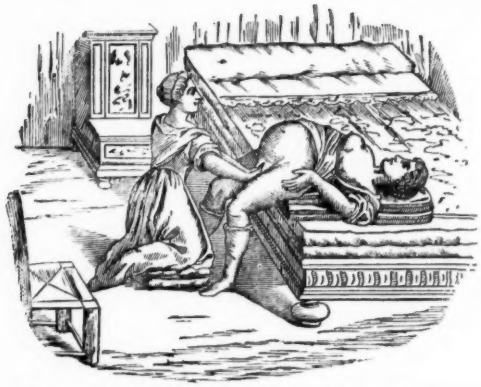

Fig. 4. The modification of the Walcher position used in medieval Italy for the delivery of fat women (after George J. Engelmann, *Labor among Primitive Peoples*. J. H. Chambers & Co.).

"The obstetric chair is required to put the patient in the proper posture for delivery. In construction it is a chair having in the center of the seat, where the birth takes place, a moderately large space cut out, round in shape. This space must not be too wide, so as to allow the hips of the patient to slip through, nor again too narrow so as to cramp the perineal region, which in the state of the patient would be painful. . . . Underneath the seat the chair should be boarded in on the right and left sides, but the front and rear should be left open for the purpose of the delivery. . . . There should also be affixed to the seat on the right and left sides two arm rests, for the patient to grasp, during the pains, and in the rear a sloping support to prevent the loins and hips slipping back."

Soranus also stated that during the earlier stages of labor the patient lay on the couch in the dorsal position until examination showed the os to be sufficiently dilated, when she was transferred to the obstetric chair. If she "was of a weak constitution" or if no obstetric chair was at hand, labor was "allowed to proceed to its termination on the couch, with this modification, however, that the final stages were completed in a squatting posture."

Engelmann (4) wrote that "the semi-recumbent positions are by far the most frequent among the ancients, especially among the more civilized people of olden times, and among the savage races of the present day. . . . The simplest of the semi-recumbent positions, which is upon a par with the customs of the rudest African races," continued Engelmann, "is sitting upon the ground, upon a stone or rude cushion, with the body inclined backward, leaning against an assistant, a tree, or some other object. A marked progress is achieved, when we find the parturient woman seated in the lap of an assistant reclining against his chest, a position which reaches its greatest perfection in the obstetric chair."

Simms states that the most interesting phenomenon in the history of obstetrics is the discontinuance "of what is probably the natural mode of delivery"—a mode that the ancients endeavored to assist by the use of the obstetric chair. The nations of the Orient still use the obstetric chair.

Of late years I have been placing almost all of my obstetric patients in the rocking chair prior to delivery until labor is well advanced. In general, the patient is given a great deal of liberty, walking is encouraged and at intervals she is urged to rest in the rocking chair instead of lying recumbent.

Markoe (11, 12, 13) states that the obstetric chair was used in Europe through the Middle Ages and up to the end of the eighteenth century; then it gradually fell into disuse, although it was still employed in some rural communities in various countries.

Largely as a result of Markoe's work, the use of the obstetric chair was again brought to the attention of the medical profession. In 1914 Markoe reported that he had devised an obstetric chair that had been used in a few cases in the Lying-In Hospital of the City of New York. In 1915 he reported 179 cases in which the obstetric

chair was used; and in 1917, 320 cases (including the first series of 179 cases). Summarizing the results in the latter series, he stated that in about 20 per cent of the cases labor lasted only an hour or less after the patient was put in the chair; in one case, in which the cervix was almost fully dilated at the time, 15 minutes was sufficient for delivery. In 18 cases in which the cervix was only one or a few fingers dilated, less than one hour was required. In 21 primiparæ, where anatomical conditions might have rendered operative interference necessary, spontaneous delivery occurred. In other words, in about 37 per cent of 56 cases the obstetric chair apparently obviated the necessity of any other artificial aid. Of 23 multiparæ with right occipitoposterior positions, 11 or nearly 50 per cent were delivered spontaneously by the use of the obstetric chair. In 1 of 4 left occipitoposterior positions, in 2 or 3 cases of transverse position, and in 1 case of chin posterior position, delivery was also spontaneous. Of 29 multiparæ with normal pelves, all but 1 were delivered spontaneously, and all but 2 of them in less than 2 hours.

In the home a rocking chair padded with pillows and blankets can be made into an excellent obstetric chair. In the first stage of labor, when regular contractions have begun, the patient may sit with her knees elevated to support the abdomen. For patients with pendulous abdomens, the chair can be tipped backward so that the axis of the uterus points directly into the pelvis, as with the hospital chair (Fig. 6).

The advantage of the use of the obstetric chair, Markoe claims, is: "the placing of the woman in the upright posture tends to give the natural expulsive forces every chance with the addition of the direct action of the weight of the child plus the fluid contents of the uterus always in a downward direction toward the point of least resistance, that is the softened cervix which nature has already prepared for dilatation. In cases in which the membranes are already ruptured the presenting parts act in the same way though naturally somewhat slower."

When the rocking chair is used in labor, the patient should recline backward and rest her feet on a stool or chair. In this way, flexion of the thighs can be regulated according to indications. She should be made as comfortable as possible by properly arranged blankets and pillows and instructed to make use of the pains by holding her breath and bearing down. Another feature of the rocking chair is that the patient can place her arms on the side rests and pull upon them during the pains, and also relax and slumber between

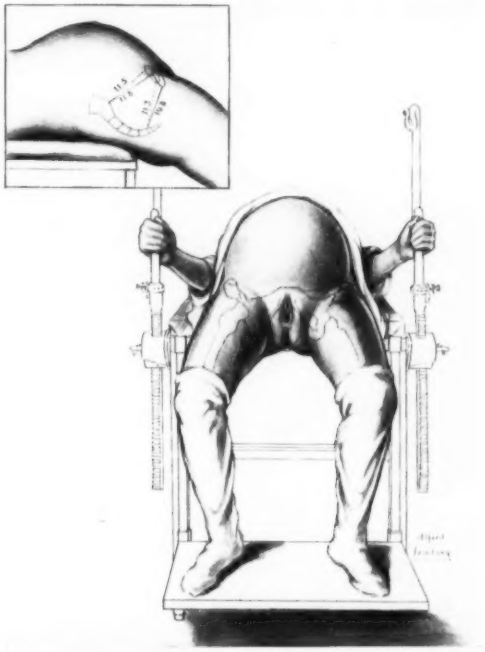

Fig. 5. The author's table. The feet rest on a sliding shelf, enabling the patient to maintain the Walcher position in comfort long enough to be effectual. The insert shows how the anteroposterior diameter of the inlet is increased by the use of the Walcher position.

them. Moreover, in the upright position the expulsive forces are used to greatest advantage to help overcome any tendency to malposition.

This posture in the rocking chair is also helpful in cases of pendulous abdomen, when the patient tires of the squatting position. In such cases, however, a higher chair should be placed under the feet, so as to flex the thighs more sharply against the abdomen and push the uterus into a better position (Fig. 6).

In 1925 Gellhorn (5) described a new delivery bed with footrests, encasing the entire foot, on a height with the table, i.e., on the same level as the patient's back. With this bed the legs are not elevated, as they are when held by attendants or by mechanical leg holders. Thus the perineum is not overstretched, the pelvic outlet is not tilted upward, and the patient is able to utilize the abdominal muscles to the best advantage. When she reaches the second stage of labor, she is moved toward the lower end of the bed until the buttocks are even with, or one-half inch beyond,

Fig. 3. Squatting position of the Tonkawas (after George J. Engelmann, *Labor among Primitive Peoples*. J. H. Chambers & Co.).

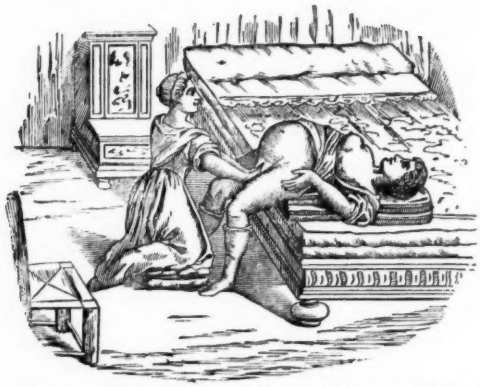

Fig. 4. The modification of the Walcher position used in medieval Italy for the delivery of fat women (after George J. Engelmann, *Labor among Primitive Peoples*. J. H. Chambers & Co.).

"The obstetric chair is required to put the patient in the proper posture for delivery. In construction it is a chair having in the center of the seat, where the birth takes place, a moderately large space cut out, round in shape. This space must not be too wide, so as to allow the hips of the patient to slip through, nor again too narrow so as to cramp the perineal region, which in the state of the patient would be painful. . . . Underneath the seat the chair should be boarded in on the right and left sides, but the front and rear should be left open for the purpose of the delivery. . . . There should also be affixed to the seat on the right and left sides two arm rests, for the patient to grasp, during the pains, and in the rear a sloping support to prevent the loins and hips slipping back."

Soranus also stated that during the earlier stages of labor the patient lay on the couch in the dorsal position until examination showed the os to be sufficiently dilated, when she was transferred to the obstetric chair. If she "was of a weak constitution" or if no obstetric chair was at hand, labor was "allowed to proceed to its termination on the couch, with this modification, however, that the final stages were completed in a squatting posture."

Engelmann (4) wrote that "the semi-recumbent positions are by far the most frequent among the ancients, especially among the more civilized people of olden times, and among the savage races of the present day. . . . The simplest of the semi-recumbent positions, which is upon a par with the customs of the rudest African races," continued Engelmann, "is sitting upon the ground, upon a stone or rude cushion, with the body inclined backward, leaning against an assistant, a tree, or some other object. A marked progress is achieved, when we find the parturient woman seated in the lap of an assistant reclining against his chest, a position which reaches its greatest perfection in the obstetric chair."

Simms states that the most interesting phenomenon in the history of obstetrics is the discontinuance "of what is probably the natural mode of delivery"—a mode that the ancients endeavored to assist by the use of the obstetric chair. The nations of the Orient still use the obstetric chair.

Of late years I have been placing almost all of my obstetric patients in the rocking chair prior to delivery until labor is well advanced. In general, the patient is given a great deal of liberty, walking is encouraged and at intervals she is urged to rest in the rocking chair instead of lying recumbent.

Markoe (11, 12, 13) states that the obstetric chair was used in Europe through the Middle Ages and up to the end of the eighteenth century; then it gradually fell into disuse, although it was still employed in some rural communities in various countries.

Largely as a result of Markoe's work, the use of the obstetric chair was again brought to the attention of the medical profession. In 1914 Markoe reported that he had devised an obstetric chair that had been used in a few cases in the Lying-In Hospital of the City of New York. In 1915 he reported 179 cases in which the obstetric

chair was used; and in 1917, 320 cases (including the first series of 179 cases). Summarizing the results in the latter series, he stated that in about 20 per cent of the cases labor lasted only an hour or less after the patient was put in the chair; in one case, in which the cervix was almost fully dilated at the time, 15 minutes was sufficient for delivery. In 18 cases in which the cervix was only one or a few fingers dilated, less than one hour was required. In 21 primiparæ, where anatomical conditions might have rendered operative interference necessary, spontaneous delivery occurred. In other words, in about 37 per cent of 56 cases the obstetric chair apparently obviated the necessity of any other artificial aid. Of 23 multiparæ with right occipitoposterior positions, 11 or nearly 50 per cent were delivered spontaneously by the use of the obstetric chair. In 1 of 4 left occipitoposterior positions, in 2 or 3 cases of transverse position, and in 1 case of chin posterior position, delivery was also spontaneous. Of 29 multiparæ with normal pelves, all but 1 were delivered spontaneously, and all but 2 of them in less than 2 hours.

In the home a rocking chair padded with pillows and blankets can be made into an excellent obstetric chair. In the first stage of labor, when regular contractions have begun, the patient may sit with her knees elevated to support the abdomen. For patients with pendulous abdomens, the chair can be tipped backward so that the axis of the uterus points directly into the pelvis, as with the hospital chair (Fig. 6).

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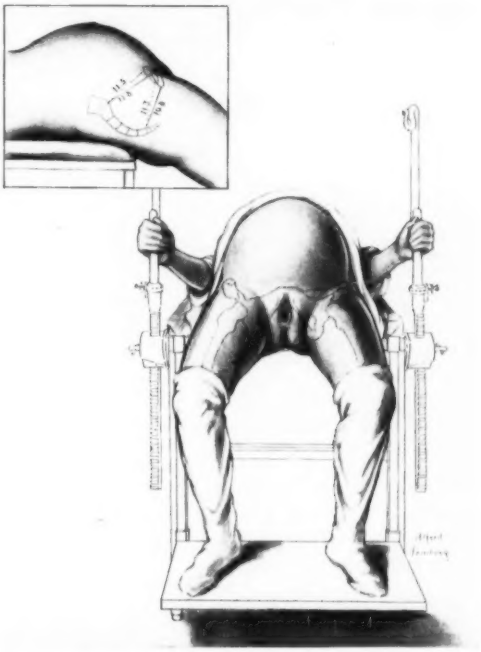

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Fig. 6. Use of the rocking chair. When the knees are flexed, the axis of the uterus points directly into the pelvis and the expulsive forces are used to greatest advantage. When the abdomen is pendulous, the feet may be placed higher and the abdomen may then rest on the thighs.

Fig. 7. The author's table with crutches shifted back to place the patient in an exaggerated lithotomy position. This posture raises the pubis and increases the diameter of the outlet.

the edge. The feet are placed at a comfortable distance in the footrests and the knee rests adjusted until the knees rest securely in them. With the patient in this position, the perineum is more relaxed than with other forms of leg holders. The entire progress of labor can be easily observed, and the position of the patient is comfortable and can be maintained for hours.

In cases of contraction at the outlet, the exaggerated lithotomy position raises the pubis and increases the diameter of the outlet. In my obstetric table I have so arranged the crutches that they may be shifted backward, thus allowing the patient to assume the exaggerated lithotomy position. One must note, however, that, although the outlet is increased by the exaggerated lithotomy position, there is a greater tendency to perineal lacerations. Therefore, unless episiotomy is contemplated, it is best to diminish the flexion of the thighs and bring the patient to a more classic lithotomy position as soon as the head is on the perineum.

When one is performing version, the patient may be placed in a modified Walcher position, the Potter position; that is, the thighs are not allowed to drop as low as in the true Walcher position. To obtain this position on my table, the crutches are allowed to drop below the level of the top of the table. This position may be held with comfort. In the home the legs may be allowed to rest on chairs. An exaggerated lateral prone position with elevated pelvis will often help to replace a prolapsed cord or small parts of the fetus.

The value of posture in the treatment of prolapse of the cord is illustrated by the following case.

Mrs. P. F., aged 25, a primipara, was admitted to the Sydenham Hospital March 25, 1928, with breech presentation. The membranes had ruptured when the cervix was only one and a half fingers dilated and the cord was prolapsed. The patient was first placed in the knee-chest position, and then the greater part of the cord slipped back into the uterus and could be felt on the external os by rectal examination. She was then placed in the exaggerated lateral prone position. The thighs were flexed on the abdomen as in the Simms position but to a greater degree, and the hips were elevated by two pillows placed under the pelvis. This posture kept the liquor amnii from draining off and permitted the cord to gravitate into the uterus. As the presenting breech receded from the inlet, the uterine contractions diminished in force and frequency. An external cephalic version was performed. The vertex engaged itself, the patient delivered naturally, and a living child was obtained.

In cases of prolapse of the fetal parts, the Trendelenburg position may be assumed instead of the knee-chest. It has the advantages that it may be maintained longer and that the patient may be anæsthetized in this position. With reference to the Trendelenburg position, it must not be forgotten that this is the most favorable one for the treatment of postpartum hæmorrhage and shock. After the bleeding has stopped, the patient should be removed from the table and placed in bed with the foot of the bed still elevated. According to Edgar (3) the Trendelenburg position is used extensively in laparotomies incidental to obstetric practice; for example, in extra-uterine pregnancy. Moreover, it may be employed as a substitute for the knee chest

Fig. 8. The author's table. The crutches are allowed to drop below the level of the top of the table. Modified Walcher or Potter's position for use in version.

position, over which it has advantages in that it is more natural and modest, can be endured indefinitely and does not conflict with the administration of anæsthesia. "The Trendelenburg position," writes Edgar, "may be improvised by various means: an incline may be formed from an inverted chair and several pillows, or the woman may rest, head down, upon the back of a strong attendant with her knee hollows upon his shoulders and her legs held in his hands."

The knee-chest position is useful for replacing the retroflexed gravid uterus during the early months of pregnancy, also for the prevention and correction of postpartum retroflexion. I advise every patient 3 weeks postpartum to assume this position for from 5 to 15 minutes twice daily. The monkey trot, recommended by Polak (14), is also a great help in correcting this displacement.

The use of Fowler's position postpartum helps drainage of the uterus and is especially to be recommended for patients who show signs of pelvic inflammation, since it favors the localization of the inflammatory process low in the pelvis.

SUMMARY AND CONCLUSIONS

1. Appropriate postures used during difficult labor frequently obviate the need of instrumental delivery or enable one to substitute a simpler for a more difficult operative procedure.

Fig. 9. An exaggerated lateral prone position with elevated pelvis.

2. The squatting position during delivery, which was much used by aboriginal women and is still employed by the Chinese, has unfortunately fallen into disuse. Yet it is undoubtedly of great aid in labor, particularly in cases of pendulous abdomen, as a preventive of transverse presentation and as an aid to weak labor pains.

3. The Walcher position increases the anteroposterior diameter of the inlet from 0.5 to 1.0 centimeters. When the pelvis is slightly contracted or the fetal head is a little oversized in a normal pelvis, the use of this position often facilitates engagement.

4. The use of the obstetric chair is a help to delivery. In the home, an obstetric chair may be improvised from a rocking chair, padded with blankets and pillows, and a couple of stools as footrests.

5. The treatment of obstetric difficulties with postures should appeal particularly to the physician in rural districts, where hospitals are inaccessible. It is eminently practical as a substitute for interference, especially when the environment is unfavorable to surgical procedures.

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MESENTERIC DEFECTS

With Special Reference to Their Etiology and Report of a Rare Case of Colonic Obstruction

JAMES R. JUDD, M.D., F.A.C.S., Honolulu, Hawaii

INTESTINAL obstruction caused by a loop of bowel passing through a slit, opening, rent, aperture, hole or hiatus in the mesentery, as it is variously called, is a rare condition. Little or nothing is written in the textbooks about this condition, but there has been considerable written in the form of case reports. Sir Frederick Treves in his *Applied Anatomy* writes as follows.

"Certain holes are sometimes found in the mesentery through which the intestine has been strangulated. Some of these holes, especially those that are slit-like, are due to injury, others are due to congenital defect of the mesentery."

Keen, Davis, Kemp, Boas and other authors briefly mention the subject. Brown, in 1920, reported a case and found only 19 cases reported in the previous 25 years and Cutler, in 1925, reported 8 additional cases, including one of his own, making 28 in all. In the literature since 1925, no further reports of this condition have been found.

It is noteworthy that in all but one of the 28 cases reported, it was the small intestine that had become strangulated. Hamaker, in 1914, reported the only case of strangulation of the colon.

The patient was a female aged 72 years, with a history of obstinate constipation for many years. There was a sudden onset of symptoms of obstruction. Operation was done on the third day after onset of acute symptoms and revealed an opening the size of an egg in the mesentery through which had passed the transverse colon and omentum. The condition was evidently of long standing. Recovery followed operation.

Hohlbaum, in a study of 3 cases of ileus caused by the small intestine entering a defect in the mesentery, drew the following conclusions: The usual location of the defect was in the lowest portion of the mesentery near the ileocæcal junction. The mesentery in that region is often found to be thin and lacking in fat and blood vessels. Trauma as a cause is rare and the presence of other anomalies indicates a congenital condition.

In the case reported by Brown the cause was evidently traumatic as the condition developed 2 days after a fall, and it was noted at the operation that the "opening in the mesentery had rough edges apparently of recent origin."

Prutz's theory that the cause is inflammatory is not substantiated by operative and postmortem findings.

In Cutler's summary of the 28 cases reported, the ages of the patients varied from 1 to 73 years. More than half the patients were under 20 years of age. A history of trauma is mentioned in 7 instances only and previous attacks of abdominal pain in 6 cases. In none of the cases reported was a correct pre-operative diagnosis made. The mortality was over 50 per cent.

The following report is made of a case in which the colon had become strangulated through a defect in the mesentery.

A Spanish boy, aged 10 years, was admitted to the Queen's Hospital, Honolulu, on February 24, 1928. There was no history of previous attacks of abdominal pain or of trauma. Three days before admission the patient was suddenly seized with abdominal pain and vomiting. Several doses of castor oil had been rejected and several enemas had been given without result. The vomiting and pain had continued and the abdomen had become distended.

Examination showed a boy in desperate condition: pulse 130; temperature subnormal; face sunken, nose pinched, badly dehydrated; abdomen enormously distended and rigid, tympanitic to percussion. No masses were made out. Rectal examination was negative. A tentative diagnosis of intestinal obstruction due to intussusception was made, although it was recognized that the characteristic bloody, mucous discharge was absent.

Operation was performed under light ether anæsthesia. Hypodermoclysis of saline solution was started at once, also intravenous injection of glucose solution. The

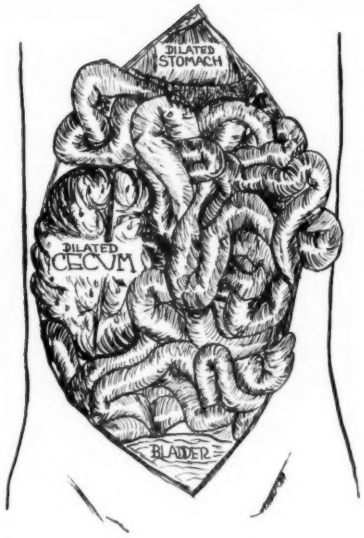

Fig. 1. Condition found at laparotomy. The gastro-intestinal tract is greatly distended to the site of the obstruction of the transverse colon.

stomach was emptied of a large amount of fæcal smelling material by nasal catheter lavage. A right rectus incision was made. There was a moderate amount of bloody fluid in the peritoneal cavity. The entire intestinal tract to the site of an obstruction of the transverse colon was greatly distended. The colon carrying with it the lower ileum was found to pass though an opening near the center of the mesentery of the small intestines. The opening was circular, about 1 inch in diameter and the margins were smooth and firm. The proximal colon was distended to the size of the child's mid-thigh. The colon beyond the constriction was flat and empty. There was a short fringe of great omentum hanging down free from the greater curvature of the stomach, also there was a rudimentary fringe of omentum coming off from the left portion of the transverse colon. The gas was evacuated by puncture of the cæcum, the colon was freed from the margins of the aperture, and the opening dilated sufficiently with the fingers to allow the colon and lower ileum to be manipulated back through the opening. The aperture was closed by a few sutures and the colon was brought forward to a normal position below the stomach. The appendix was removed as a precautionary measure. The congested, purplish bowel responded satisfactorily to the influence of moist heat, so the abdomen was closed without drainage.

The patient had a stormy postoperative 3 days. Reliance was placed on salt solution and glucose given intravenously and by rectum, also the use of a 2 per cent solution of ammonium chloride as recommended by Haldane, Ellis, and others for the purpose of restoring the blood chlorides. The abdomen was exposed to the sun's rays every day commencing with a 10-minute exposure and increasing 5 minutes a day to 35 minutes. This valuable method of treatment is possible in Hawaii even in February. The boy made an excellent recovery and walked out of the hospital on the twentieth day.

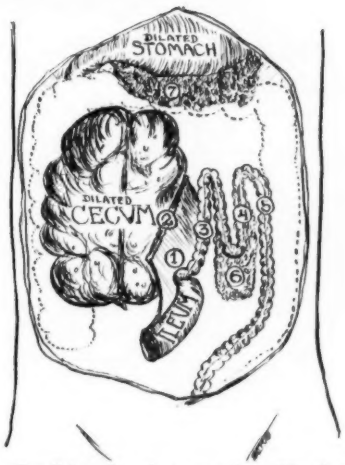

Fig. 2. Conditions found at operation. The dotted line indicates the proper position of the colon. *1*, Position of mesenteric defect through which transverse colon and lower ileum had become strangulated. *2*, Cut edge of mesentery; *3*, *4*, *5*, empty colon; *6*, rudimentary omentum; *7*, fringe of omentum from lower border of stomach.

ETIOLOGY

The three causes given for this condition are inflammation, trauma, and congenital defects. Inflammation as a cause is discredited by the operative and postmortem findings. Trauma, because of the history and signs of recent injury found at operation, must be accepted as a cause in some instances.

Congenital defects of the mesentery are responsible for the majority of cases reported. It is an interesting question whether there is a pre-existing, actual absence of tissue in the mesentery through which a loop of intestine finds its way by accident or whether there is some definite factor that forms these abnormal openings and accounts for the hernia of the intestine.

According to the researches of Mall, at the seventh week of fetal life the rapidly increasing liver occupies so much space in the small abdominal cavity that there is insufficient room for the expansion of the intestinal tube. The greater part of the intestine in consequence is displaced from the abdominal cavity into the cœlum within the umbilical cord. At 10 weeks, on account of the increase in size of the abdominal cavity, the intestine returns from the umbilical cord into the abdominal cavity and the cœlum of the cord is obliterated soon afterward. "Once back in the peritoneal cavity, the loops which collectively lay in the sagittal plane of the cord, are arranged

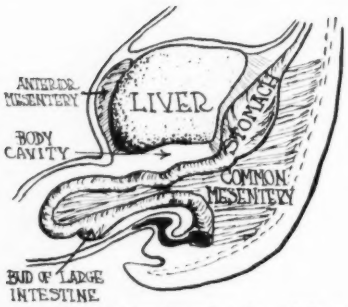

Fig. 3. Diagram showing the migration of the intestinal tube into the umbilical cord in seventh week of fetal life. (Modified from Piersol's *Human Anatomy*.)

generally at right angles to the long axis of the body, and the anteroposterior colon becomes transverse." (Mall). The portion of the colon that lay within the cord now lies obliquely across the abdomen in front of the duodenum.

In attempting an explanation of this rare form of hernia, it is reasonable to assume that the abnormal opening in the mesentery is caused by pressure rather than that the opening existed as an actual lack of tissue through which the intestine subsequently found its way. The fact that the greater part of the gut is displaced from the abdominal cavity into the umbilical cord indicates that the pressure to accomplish this purpose must be considerable. Figures 4 and 5 show the possibility

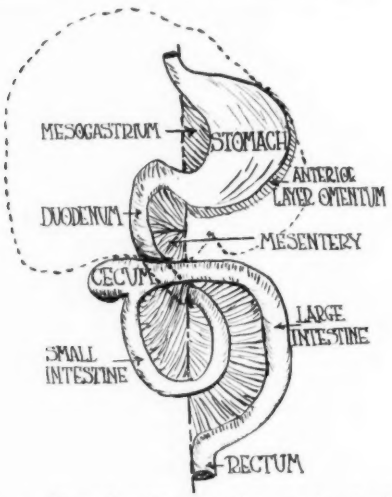

Fig. 4. Normal position of colon crossing duodenum during fetal life. Dotted line outlines the liver. (Modified from Tourneux.)

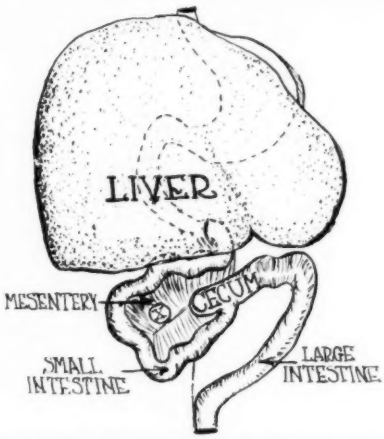

Fig. 5. Diagram illustrating the possibility of the cæcum being pressed through the mesentery by pressure of rapidly growing liver.

that sufficient pressure exerted against the colon might influence its position so that instead of crossing the duodenum at this period it might lie to the left of the small intestinal loop. The pressure, continuing as the intestine migrates into the cord, might cause the colon to continue along the path of least resistance and gradually force its way though the delicate structure of the mesentery.

Fusion of the omental sac and the transverse colon and mesocolon takes place in the fourth month of the fetal life. As fusion had not occurred in this case reported, it is evident that the misplacement of the colon must have occurred at an early period.

SUMMARY

1. Intestinal obstruction caused by the intestine passing through an abnormal opening in the mesentery is a rare condition, only 29 cases having been reported.

2. Strangulation of the colon in this manner has been reported only in one instance (Hamaker). The report of this case makes the second case report of colon strangulation.

3. In Hamaker's case the condition was evidently acquired. In the present case report the condition was congenital. Apparently this is the first case report of strangulation of the colon through a congenital mesenteric defect.

4. The migration of the intestinal tube from the abdominal cavity into the umbilical cord at the seventh week is caused by pressure of the rapidly growing liver. In rare instances, this

pressure may be so directed that the intestine is gradually forced through the delicate membrane of the mesentery.

5. The pressure theory makes the causation of the condition easier to understand than the idea that there is a pre-existing lack of substance in the mesentery through which the intestine finds its way later on.

6. Embryological defect may be considered to be the cause of the condition in the majority of cases occurring in the young. Rarely trauma may be responsible for the aperture in the mesentery as in Brown's case in which the opening showed ragged edges. Trauma may act by precipitating a strangulation in a pre-existing hernia through the mesenteric aperture.

7. There are no pathognomonic symptoms to distinguish this condition from other forms of intestinal obstruction and a correct pre-operative diagnosis has never been made. Possibly X-ray examination may lead to correct diagnosis in the future.

8. Operation is imperative. Lavage, water, glucose, and chlorides are indicated as in intestinal obstruction in general.

My thanks are due to Dr. F. J. Halford for his assistance on the case and for the drawings.

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HEREDITARY DEFORMING CHONDRODYSPLASIA

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AT the end of a lecture upon tumors, that formed part of the instruction in general pathology given to students in the Evans Institute and Department of Dentistry of the University of Pennsylvania, a young man presented himself remarking that he thought certain tumors in various parts of his anatomy might be of interest to the professor.

The man, of English and Scotch ancestry, has been American for four generations. He is 22 years old, 5 feet 6 inches in height, and weighs 126 pounds. He is fair and has curly, chestnut colored hair in abundance upon his head, with scarcely any upon the face, which is bright, cheerful, and boyish. He is very intelligent and a good student, having been educated at Union College in Schenectady, New York, before beginning dentistry.

At first glance one notes that he built along somewhat peculiar lines. The head is normal in size (he wears a 7¼ hat) and shape, but the neck is long. The body appears to be of usual size, but the limbs, especially the arms, seem short, and the hands turn outward at the wrists as is particularly noticeable when he shakes hands.

Nothing unusual was observed during his babyhood, and he was 4 years of age before his mother, while giving him a bath, discovered that he had peculiar hard lumps on the left knee, the wrists, and the ribs. When he was about 8 years of age hard nodules were felt between the bones of his left forearm. When about 12 years of age he noted that the calf of his right leg was developing, but later found that the enlargement depended upon the presence of another bony lump. Not long afterward he felt another similar lump on the outer side of the left humerus near the shoulder, and a little later noted two others at the lower end of the right femur, and a larger one in a similar position on the left. When about 16 years of age, he discovered a lump on the inner side of the left humerus below the shoulder.

Since their discovery various changes have been observed in these tumors. Those on the ribs and at the knee seem to have disappeared, though the patient thinks that the left knee has increased in size; those near the left shoulder have grown larger; the wrists and legs are thought to have remained unchanged. The existing nodes or tumors are mostly large enough to be distinctly felt as hard, bony, tumor-like excrescences immovably attached to the respective bones.

No pain or disability has ever been experienced except that the left shoulder sometimes "catches," and that the left leg feels "tired" after a long walk, but he is uncertain whether the latter depends upon the lesions as wearing garters produces a similar feeling. There is sometimes tingling in the left upper arm. He thinks that the motion of all of the joints is normal, but it is certainly diminished as regards the left shoulder, and the pronation and supination of the arms are diminished, perhaps one-third on the left and nearly one-half on the right side. When the hands are held in the supine position with the palms up, they turn out at a distinct angle.

The patient is not conscious of any particular physical disability resulting from the bony deformities, nor has he found himself hampered in any way. He plays the piano, tramps, runs, skates, swims, wrestles, rides a bicycle, and has played baseball. He does find, however, that his left wrist is easily "sprained."

X-ray examination. An examination of the skeleton by the X-rays was made through the kindly co-operation of Dr. H. K. Pancoast, to whom I here express my thanks.

The skull showed no bony malformation, deformity or disease of any kind.

The spinal column: The four upper cervical, the three lower dorsal, and all of the lumbar vertebræ, the sacrum, and coccyx were examined. The lower cervical and upper dorsal vertebræ escaped examination. The only defects observed were a bony tubercle the size of a split-pea that arose from the right lateral surface of the spinous process of the third lumbar vertebra, and a defect of union between the laminæ (spina bifida occulta) of the first sacral vertebra, which has no spinous process, but an oblique diagonal fissure, coursing from upper right to lower left. The lamina on the right side forms a rounded eminence with a small spur to the left, the left lamina extends farther upward, is longer, but also ends abruptly and bluntly.

The ribs show no pathological changes.

The clavicles: The acromial end of the right clavicle casts so dark a shadow as to give the impression that most of it is cartilaginous in structure. From the anterior inferior surface, 3.5 centimeters from the acromial extremity, a rounded cartilaginous mass about 1.5 centimeters wide arises and descends so as to appear in contact with the coracoid process of the scapula. The corresponding end of the left clavicle shows much the same lack of bony structure, and from its inferior surface a more flattened cartilaginous outgrowth arises about 1 centimeter from the acromial end, and descends only about 0.5 centimeter, not coming into relation with the coracoid process. The sternal ends of the clavicles are not shown in the plates.

The scapulæ: As much of the right scapula as shows in the plates is without abnormality. The outer border of the left scapula, along the attachment of the rhomboideus muscle, and at about the altitude of the third rib, shows an anterior cartilaginous tubercle 0.75 centimeter in diameter, just below which a short spur projects externally.

The humeri: The entire head, anatomical neck, and tuberosities of the *right humerus* seemed to be largely composed of cartilage or of very poorly formed bone. Along the inner aspect of the shaft, probably about the position of the origin of the teres major muscle, there is a rarefaction and thickening of the compact bone with a slight spur. The distal end of the shaft with its condyles seems to be normal. The *left humerus* shows two of the most important lesions. The head is nearly normal, though the osseous tissue may be less dense than ordinarily. But from the shaft at a level of 9 centimeters from the upper surface of the head of the bone, and from bases 3 and 4 centimeters broad, respectively, there arise two osteochondromata. The larger of these projects antero-interiorly, is the size of a plum, and although generally rounded, is more or less divided. Its substance seems to be composed of cartilage with trabeculæ of bone. The second, on exactly the same level, projects antero-exteriorly, is of similar construction, but is bilobed. The relation of the bicipital groove to this tumor cannot be made out in the X-ray plate. The shaft

Fig. 1.

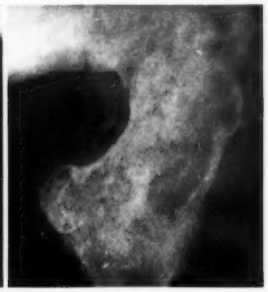

Fig. 2.

Fig. 1. Left shoulder as it appeared October 20, 1924.
Fig. 2. Left shoulder as it appeared June 11, 1925.

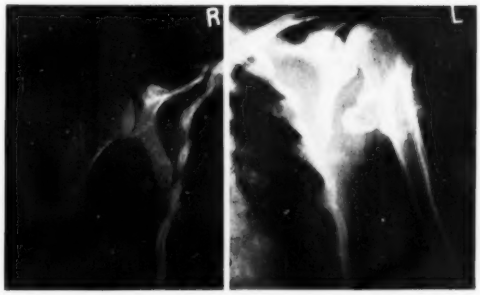

Fig. 3. Shoulders as they appeared January 26, 1928. The change in the shape of the internal tumor is very distinct; the anterior external tumor appears to be an entirely new growth.

and distal end of the bone appear to be normal. Both humeri seem to be somewhat shortened, but measurement shows them to be approximately 28 centimeters in length. The radii and ulnæ show remarkable and interesting changes that give the forearms a peculiar deformation. The right forearm has suffered less than the left and is a little longer. The upper halves of both bones of the forearms seem to be normal in almost every way. The right ulna, from the tip of the olecranon to its opposite end, measures on the X-ray plate exactly 18.5 centimeters, the radius, from the flattened summit of its head to the tip of the styloid process, 21 centimeters. At 14.5 centimeters below the tip of the olecranon, the shaft of the ulna gives off several blunt, broad spurs, one internally, one externally, and perhaps one anteriorly, each about 1 centimeter at the base. At this point the osseous tissue becomes porous and gradually tapers to a blunt point tipped with cartilage. The ulna, at its inferior extremity, lacks 2 centimeters of reaching the wrist joint, and does not touch the radius. The *right radius*, except that it is more than ordinarily curved and has a small pointed spur arising 3 centimeters above the styloid process, is normal.

The *left ulna* also measures 18.5 centimeters in length and is normal at its upper end, remaining so until a point 7.5 centimeters above its tip is reached, where it gives off an osteocartilaginous formation having a base of nearly 3 centimeters, a greatest projection of 1.2 centimeters, and meeting, by an irregularly flattened surface, a similar but smaller malformation springing from the radius as though to meet it. Below this growth the shaft of the bone continues normal for 3 centimeters when it abruptly terminates in a sharply margined, regularly rounded extremity, from the apical convexity of which a small osteocartilaginous mass, 0.7 centimeters in diameter and of rounded form, springs. The *left radius* is quite normal from its head to a point 11 centimeters below, where it suddenly broadens and gives off, on the ulnar side, a broad flattened exostosis (?) as though to articulate with that upon the ulna. It is difficult to escape the conviction that in the pronation and supination of the hand these exostoses play upon one another in such a manner that each meets the other by a broad flat surface (pseudarthrosis). Except for the increased breadth already mentioned, and a little pointed spur like that upon its fellow of the other arm, the distal end of the bone is normal.

The *carpal bones* all appear to be normal. The metacarpals of the third and fourth fingers of the right hand are shorter by 0.5 centimeter than the corresponding bones of the left hand. The *phalanges* all seem to be normal.

The shortening of the ulnæ, and their failure to play their customary small parts in the formation of the wrists, determines that each hand turns toward the ulnar side to an extent that strikes the observer as unusual. The right hand turns a little more than the left, and its position may have something to do with the shortening of the inner metacarpals. As the left ulna is more widely separated from the wrist, it is probable that it would turn in more, were it not for the support the ulna receives through its exostosis meeting the radial exostosis, and keeping it rather widely separated and affording the wrist some breadth of support.

The *ossa innominata*, only partly shown in the X-ray plates, seem to be without interest.

The *femora* are generally well developed, and apparently of about normal length. They show no distinct pathological lesions. The lower legs show abnormalities analogous to those seen in the left forearm.

The *right tibia* measures 35 centimeters in length. The head and upper two-thirds of the shaft are generally well-formed, except that on the inner side below the internal tuberosity and at about the level of the tubercle, there is a small projecting spur of bone. About the junction of the middle and lower thirds, there is a point 5 centimeters in extent in which the X-ray picture is a little confused, but at which a broad flat exostosis seems to arise to meet a similar exostosis projecting from the fibula, forming a condition homologous with what was found in the left forearm. As the lesions superimpose it is difficult to make out the precise outlines of either or to say which was the larger or how their surfaces came into contact. Below this point the bone loses its outer compactness and the medullary cavity its distinctness, and for some 5 centimeters the bone becomes more and more cartilaginous, until at the internal malleolus it consists almost entirely of cartilage.

The *right fibula* is much altered. Its head, which is large and has a sharp spur externally, is largely cartilaginous and gives off anteriorly, an osteochondromatous mass that measures 5 centimeters in the length of its attachment and extends anteriorly 3 centimeters to the crest of the tibia. At a point 7 centimeters below its upper extremity, the shaft of the bone becomes normal and remains so for 10 centimeters, when it gives off from the inner aspect, the exostosis to meet the similar lesion arising from the tibia. The lower end of the bone, like that of the tibia, is very porous—probably largely cartilaginous—and has several large rounded but somewhat flattened protuberances.

The *left tibia* has a head much diminished in density, presumably because of an excess of cartilage. It is generally

Fig. 4. Fig. 5.

Fig. 4. Left forearm as it appears in the roentgenogram made June 11, 1925.

Fig. 5. Forearms as they appeared in roentgenograms, January 26, 1928. There seems to be no difference in the lesions of the left side.

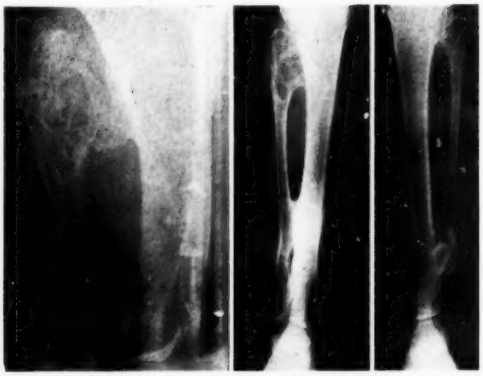

Fig. 6. Fig. 7.

Fig. 6. Upper end of right fibula as in October, 1924.

Fig. 7. Lower legs on January 26, 1928. Comparison shows that some of the exostoses present at the earlier date have diminished and that the tibia and fibula are in closer relationship with one another.

well shaped and of normal length (35 centimeters). But at about the junction of the upper three-fourths with the lower fourth, an exostosis is given off externally to meet a similar one springing opposite to it from the fibula, just as in the other leg, though slightly smaller and on a lower level. Again overlapping confuses the X-ray picture, but one gets the impression that the projection from the tibia is denser and more completely ossified than that from the fibula. Below this point the shaft of the bone is less well formed, and the internal malleolus seems to be largely cartilaginous.

The left fibula is much like the right. The head is large, irregular, largely cartilaginous, and has a good sized external spur. Between the articulation of the head of the fibula and the tibia there is indefinite indication of irregularities on the surface of the tibia, though all may really depend upon the large and imperfect head of the fibula. The shaft is well formed to the point at which the osteochondrous mass is given off to meet that arising from the tibia, and there and from there down, its substance is confused and largely cartilaginous. There is a little mass of cartilage at the tip of the external malleolus. The bones of the feet were not examined.

The patient was formerly a student at Union College, Schenectady, New York, and while there, X-ray plates were made of a few bones in October, 1924. Fortunately some of them are still in existence and have been lent in order that his past and present conditions may be compared. These plates, made when the patient was about 18 years of age, leave much to be desired, but show the upper end of the left humerus, the lower part of the left radius and ulna, and the upper ends of the right tibia and fibula—the points at which some of the most interesting of the lesions occur.

Two plates showing the left humerus are dated October, 1924, and June, 1925. They are, unfortunately, very dark, but they both show that at 12 centimeters from the upper end of the bone, the point at which the upper and middle thirds join, the shaft completely loses its compact tissue and rapidly increases in breadth in the direction of the head, chiefly through the formation of a large blunt process that arises from a base approximately 6 centimeters in length, projects fully 3 centimeters and has a broad, rounded summit with a slight dent on the upper surface. The whole of this upper end and this process seem to consist of cartilage with scattered trabeculæ of bone. On the external surface there is no process or ecchondrosis, but a small spur appears almost opposite to the lowest point of the increase in thickness. The clavate end of the humerus seems to lack the tuberosities and the anatomical neck is scarcely discernible. The large ecchondrosis is broader and blunter in the older plate, and in the 4 years intervening between the studies made at Union College and those here recorded, there have been marked changes, for the bone has become more shapely, and the tuberosities and anatomical neck have differentiated, though the tissue remains largely cartilaginous. The large blunt process has apparently elongated in its projection—it is now nearly 4 centimeters beyond the line of the shaft, but has lost much of its original, bluntly conical form and narrowed from above downward at its base until its shape is not unlike the end joint of the forefinger. It has also become trabeculated with bone. But while this lesion visible in the old plate has become

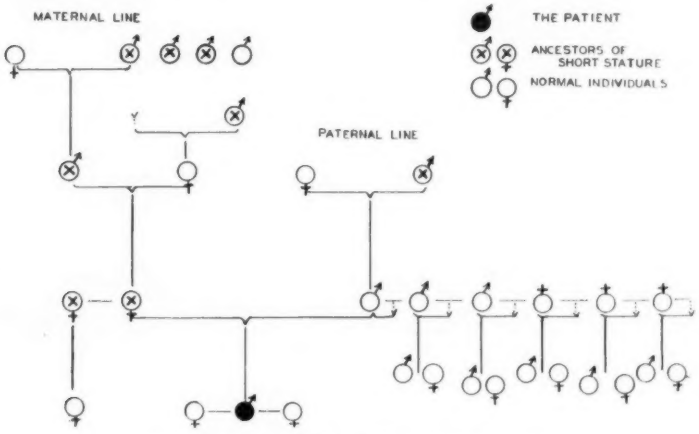

Chart showing familial influences in author's case.

modified, a second exostosis that cannot be seen in the original roentgenogram, has appeared and grown to an equal size and less regular shape.

The lesions of the left radius and ulna as shown in the old and new plates appear to be identical. The only difference is the presence of a tiny blunt spur of bone that springs from the outer side of the ulna 3 centimeters from its tip, and has now entirely disappeared.

One gets the probably correct impression that the bones in the later shadows are longer and a little more slender than in the earlier ones, but accurate comparisons are impossible because of the slightly different positions from which the respective plates were made.

The upper part of the right leg shows the general conformation of the head of the tibia to be about normal, though probably largely cartilaginous, but the head of the fibula forms a great irregular knob of cartilage with trabeculæ of bone and ecchondroses projecting externally, anteriorly, and internally so as to keep fibula and tibia unduly separated. In the later plate of this region the external projecting ecchondrosis has almost disappeared, and the internal mass has diminished or had its direction shifted so that the bones are almost normal in their approximation.

Unfortunately there were no plates to show the lower ends of the bones, so it is not known what may have been the condition of the exostoses—if they existed, as they probably did—then.

Having learned that the disease seemed to be hereditary in character, the patient almost immediately thought of his maternal grandfather as the source of his trouble, basing the suspicion on the fact that that ancestor is short in stature, with short arms, and a general configuration resembling his own. This view of the situation was tentatively accepted, and in order to confirm it as nearly as possible, the patient consented to persuade his grandfather—now an incapacitated aged gentleman,—to have part of his skeleton roentgenographed. Sufficient scientific interest was aroused, and the desired end was achieved. The result, was, however, unexpected and disappointing, for all examined parts of the skeleton proved to be perfectly normal.

Short stature runs through both sides of the patient's family, but it is not dwarfing, and though it excites interest in the mind of a student who is trying to trace family relationship in a patient with this commonly hereditary condition, may have nothing at all to do with it. All efforts to find definite inheritance or trace positive familial influences in the present case came to nothing.

HISTORY

This subject has been so carefully reviewed by Albert Ehrenfried in three easily accessible contributions that all that seems necessary in the publication of a new case is to refer to his papers, abstract his findings, and add any advances to knowledge that have been made since 1917, when his last writings appeared. In summarizing the chief features of the condition under consideration, Ehrenfried finds it characterized by:

"The occurrence of multiple, more or less symmetrical cartilaginous or osteocartilaginous growths within or upon the skeletal system generally benign and resulting from a disturbance in the proliferation and ossification of bone-

forming cartilage. Hyperostoses above the affected epiphyses are the rule, but true exostoses are less frequent and of secondary consequence.

"The occurrence of certain typical secondary distortions and deformities of the skeleton.

"The demonstration of inheritance in a large proportion of the cases."

After considering the various names that have been applied to the condition and the various explanations for its occurrence that have been offered, he comes to the conclusion that it is a chondrodysplasia of hereditary or congenital origin accompanied by secondary deformities and elects to name it "hereditary deforming chondrodysplasia." Although objected to by a few, and, therefore, not universally adopted, that name appears to be well founded both etiologically and pathologically and most appropriate.

From the literature collected and reviewed, Ehrenfried concludes that a total of 99 cases have been reported as occurring in the United States. The total number of cases reported the world over, in between 350 and 400 articles upon the subject, is in the neighborhood of 700.

Of the cases generally recorded in the literature 60 per cent are German; 27 per cent French; 8 per cent English, all other countries 5 per cent. Of the 99 reported American cases, there were 26 of Dutch origin, 18 of German origin, 3 of Irish origin, 2 negroes, and one each Italian, Austrian, English, French-Canadian and mixed French-Canadian and English. Of 89 American cases 66 were males and 23 females—a ratio of about 3 to 1.

In the literature prior to 1890, much of which was rather vague, Reinicke was able to find 36 families in which 172 cases occurred. Of them one showed the condition in five generations; two in four generations; fifteen in three generations, and twelve in two generations. In 234 more recent cases, Ehrenfried found heredity to be shown in 176. Of these, 174 cases occurred in 42 families. In two families it could be traced through four generations; in fifteen, through three generations; and in twenty-one, through two generations. In his last paper Ehrenfried cites the interesting family, reported by Montgomery, in which there were five cases in three generations, and one of his own with eight cases in three generations.

The line of descent is more apt to be the paternal than the maternal. Thus Ehrenfried found it transmitted by fathers 35 times, by mothers 20 times. One father had affected children by two marriages; two mothers had affected children by different husbands. In two cases it was transmitted by unaffected mothers, and in two instances it was seen to skip a generation.

Ehrenfried excised a portion of one of the affected bones, passing through the epiphyseal junction, and studied the lesion microscopically. He says:

Under the microscope the resemblance to chondroma is striking. This extends for some distance up and down the shaft so that the end is usually ballooned out, with a thin irregular cortex, and in the roentgenogram it is greatly rarefied so that it has much the appearance of a cyst. What little ossification there is in the cartilage shows up in five strands running up and down and obliquely across the irregular cystic space. The roentgen-ray shows the epiphysis to be small or misshapen, the intermediate cartilage narrow, irregular oblique or zigzag and sometimes prematurely ossified.

Scattered along the thickened and hyperactive periosteum of the end of the shaft are to be found clumps or nests of cartilage cells persisting uncalcified where they were left in the process of growth. These groups may develop later into cartilaginous exostoses or chondromas.

Of the secondary deformities, he says:

There are certain secondary and characteristic deformities, more marked, of course, as the child grows older and consequent on the retardation and faulty line of growth. A shortness of stature is practically constant. The patients are always of medium height or below and sometimes they are so dwarfed as to resemble a cretin. Curiously the lack of growth is in the legs and not in the trunk and the longitudinal center of the body will be found, not at the pubes, but some distance above it. The upper limbs are also short. This retardation is always, within certain lines, symmetrical.

The next most characteristic deformity is a relative shortening of the ulna. The radius is less affected than the ulna; its growth in length is, accordingly, less defective. It outstrips the ulna in its development, and sometimes has to give way. Usually the radius dislocates at its upper end and protrudes under the skin in the region of the external condyle which is atrophied or underdeveloped. This condition has frequently been miscalled "congenital dislocation of the radius." Less frequently the radius dislocates at the carpal end, throwing the hand way over to the carpal side so that it may even stand at right angles to the forearm. Once in a while the interosseous membrane gives way and the radius bows outward, dislocating at either end. In rare instances the relation between radius and ulna has been found reversed.

Other characteristic deformities, which I shall merely mention, are a high grade of pes valgus, depending on a disproportionately greater retardation in the fibula than in the tibia, and knock-knee.

Rarely the reverse deformity, varus, has been noted. Scoliosis, which is probably secondary to some relatively slight asymmetry in the growth of the legs, is not uncommon. Irregular and jagged hyperostoses are frequently found about the affected epiphyses in the adult, and occasionally an exostosis on the shaft of a long bone.

Besides the limbs we find the pelvis and scapula frequently affected. The pelvis is likely to be encroached upon, or deformed to such a degree that it endangers life in childbirth. Drescher's patient, for instance, died and the baby was found to be affected.

Tumors of the scapula develop to such a size that a considerable depression is made in the chest, involving three or more ribs.

The ribs, themselves, often show exostoses and sometimes synostoses developing from the head, angle or costo-

chondral junction. Here we commonly have a well-defined rosary.

The clavicle and spine may show outgrowths as well. On the head exostoses sometimes appear on the lower jaw or about the base of the skull. The most typical occurrence here is at the spheno-occipital junction, small outgrowths (ecchondrosis spheno-occipitalis, Virchow), being found at this point in most necropsies on chondrodysplasic subjects."

Ehrenfried's remarks upon the course and complications of the disease are interesting:

Most cases become stationary at about 22 years of age and regress slightly. A few cases have febrile attacks, but most cases have no symptoms. Many never know that they have the disease until rounded up and examined in an effort to determine the heredity in some family. Even with considerable deformity function is usually good, though a bad valgus is likely to be troublesome.

Occasionally a large hyperostosis will impede action or a pointed one cause pain. Such have been known to perforate the bladder or a pregnant uterus. Many of the projections develop bursæ which may be subject to the same inflammations and enlargements that affect other bursæ. There are seven cases on record in which, as the result of trauma, a large artery—femoral or popliteal—has been torn on the apex of a bony outgrowth causing an aneurysm.

There are two cases on record of paralytic club foot from involvement of the peroneal nerve in a hyperostosis, and one of fatal spastic paresis from bony growths in the spinal canal, and there are a few questionable cases of intracranial growths.

The most frequent and most serious complication is the development of a rapidly growing or malignant osteocartilaginous tumor in persons affected with this disease. Lenormant and Lecène in 1905 collected 24 cases of this nature, most of them fatal, and the later literature contains about a dozen more, which would figure about 5 per cent of the total number of cases. The ages at which this malignant development has been noted, lie between 11 and 59 years, but it usually occurs after the skeletal growth has ceased, or between 25 and 35 years.

Any increase in the exostoses after the cessation of skeletal growth should be treated with suspicion and surgical steps taken at once, excision being carried well into the normal cortex and medulla.

Beyond this, treatment is indicated only when the removal of a bony growth will facilitate joint function or osteotomy correct a disabling deformity.

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PHRENICECTOMY

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THE indications for phrenicectomy are lesions which may be benefited by partial compression and immobilization of a lung. These lesions include unilateral tuberculosis of the lung, especially cases in which the lower lobe is chiefly affected, and in which adhesions of the pleura preclude artificial pneumothorax; lung abscess; and bronchiectasis of the lower lobe of the lung. Phrenicectomy is often done as a preliminary to extra-pleural-thoracoplasty to see how well the patient will tolerate collapse before the more thorough, but more radical, operation is performed. Occasionally in plastic procedures in the lower chest, diaphragm and œsophagus, where the diaphragm itself is used to fill in or cover up a defect, its immobilization by phrenicectomy is desirable.

The dangers to be feared, either during or after the operation, are very few. During the operation carelessness may result in injury to one of the arteries branching from the thyroid-axis. The external jugular vein is occasionally cut, usually voluntarily, and inasmuch as it can be easily ligated scarcely can be considered in the light of a complication. Injury to the thoracic duct, especially in operations upon the left side, occasionally occurs and results in lymphatic drainage from the wound, drainage which usually stops spontaneously after a few hours or days. The unskilled operator may injure some of the nerves going to make up the brachial plexus, mistaking these nerves for the phrenic nerve. The same can be said of the cervical sympathetics. If the cervical sympathetics are injured, a temporary disturbance of function of the muscles of the pupil of the eye on that side may result, and occasionally an anopthalmus. One danger which exists is that the accessory phrenics in their course to join the main phrenic may pass under the subclavian artery, the innominate artery, or one of the large branches, or a large intrathoracic vein. Cases have been reported in which an uncontrollable hæmorrhage has occurred from injury to these vessels during the evulsion of the phrenic nerve. These anomalies are rare. Furthermore, the accessory phrenic nerves are usually so delicate that their tensile strength is much less than that of the vessels under consideration, and therefore tear first without injuring the vessel. To my mind the more radical operations which have been devised to avoid the possibility of injury to the vessels entail more risk than the danger they attempt to obviate.

The dangers resulting from paralysis of the diaphragm are nil. It was first thought that paralyzing the diaphragm might interfere with the raising of sputum from the affected lung. This has not proved to be the case. The patient still can cough. In fact, frequently one of the first benefits the patient sees from the operation is that "the cough is easier." This is due to the abolishing of the diaphragmatic spasm which frequently exists and which makes coughing difficult.

It was also feared that there would be insufficient aeration of the lower lobe of the lung because of loss of diaphragmatic motion and that as a result a hypostatic pneumonia might develop. This also has been shown to be a groundless fear.

The operation is performed under local anæsthesia. The patient requires no pre-operative preparation outside of cleaning and shaving the neck, or in apprehensive patients the administration of a hypodermic of morphine a half hour before operation. There is no need to vary the patient's usual hospital routine, nor even to interdict breakfast the morning of the operation. The patient lies upon the operating table in the usual recumbent position, with the neck hyperextended by a sand bag placed under the shoulders. The head is turned slightly laterally in what photographers would term a half profile, exposing the side of operation. The lateral border of the sternocleidomastoid muscle is usually readily palpated through the skin. The incision should start slightly medial to its lateral border, about two and one-half fingers' breadth above the clavicle, and should run directly lateral for a length of from one to two and one-half inches, depending upon the amount of the patient's subcutaneous fat. The skin and subcutaneous tissues over the site of incision are infiltrated with a few cubic centimeters of one-half per cent procaine solution. The incision is made through its entire length with a single sweep of the scalpel as in a goiter operation, so that the resultant scar will not be marred by the nicks of hesitation. In cutting through the subcutaneous tissues we may find it necessary to cut and ligate the

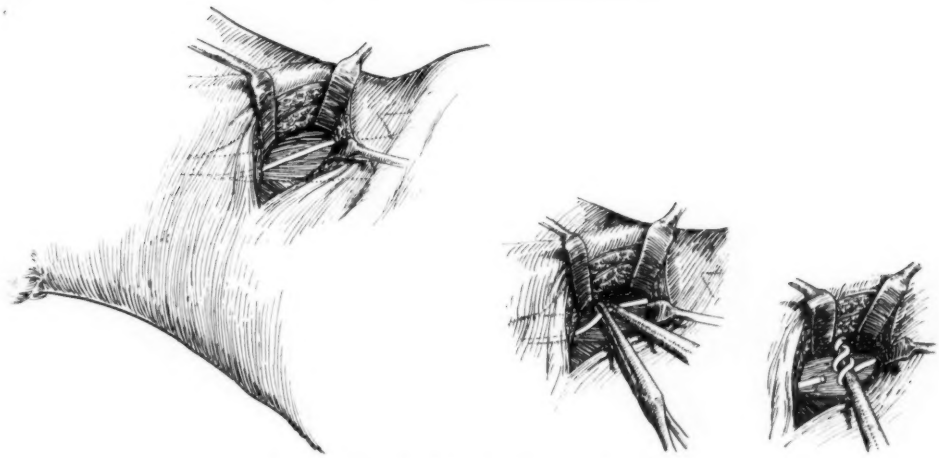

Fig. 1. Steps in author's technique of phrenicectomy.

external jugular vein, but as a rule the vein will be found to lie lateral to the incision. A tough fascia is next encountered. A few drops of procaine solution should be injected through the fascia into the tissue below it, and then with care this fascia is cut in a direction parallel to the previous incision. Under this fascia lies a pad of fat. If the finger is now inserted into the depth of the wound the scalenus anticus muscle can be readily palpated. This muscle is now exposed by careful, blunt dissection. I prefer using for this dissection the well known Mayo dissecting scissors. It is during this stage of the operation that a careless operator can injure some of the large vessels coming from the thyroid axis.

As soon as the scalenus anticus muscle is exposed a search is made for the phrenic nerve which lies under a thin integument that covers this muscle. The phrenic nerve is readily recognized by the direction it takes in crossing the scalenus anticus muscle. Instead of coursing in the direction of the nerves which make up the brachial plexus, that is slanting from above inward to below outward, the phrenic nerve first appears on the *outer* border of the scalenus anticus muscle, crosses the scalenus anticus muscle downward and inward, finally to disappear into the anterior mediastinum over its inner border. This direction is so different from that of any other nerve that there should be no question whatsoever in the mind of the operator whether or not it is the phrenic nerve which he has exposed. The phrenic nerve itself varies in thickness from a nerve about the size of the lead in the average lead pencil to one the size of a piece of woolen yarn. If any doubt still remains as to the identity of the nerve which has been exposed, a very simple procedure can be used to remove all question. If the phrenic nerve has not been anæsthetized and is pinched with a pair of tweezers, the patient will frequently complain of a twinge of pain in the region of the homolateral shoulder blade, or the patient may hiccough.

After having established definitely the identity of the phrenic nerve a few drops of procaine solution are injected into the nerve itself. The nerve is then grasped with a tissue forceps and cut near the upper outer border of the scalenus anticus muscle. The proximal cut end should be observed for a moment or two for possible hæmorrhage from a small concomitant blood vessel. The distal cut end is then firmly grasped with the hæmostat and pulled upward into the wound. With another hæmostat a firm grasp is then taken on the nerve and the nerve slowly evulsed by winding it upon the second hæmostat. The evulsion should be slow and steady—a half turn of the hæmostat every five or ten seconds is made until several inches of the phrenic nerve have thus been evulsed. Some operators continue the evulsion until the phrenic itself is torn loose; others are satisfied in cutting the phrenic nerve after from two and one-half to three inches of nerve have been evulsed. The wound is inspected for bleeding. None being found it is closed with two or three subcutaneous sutures of No. o or No. oo catgut and an intracuticular stitch of silkworm-gut, no drainage being neces-

sary. A small gauze pad is placed over the wound, held there by adhesive, and the patient returned to his room. Examination with a fluoroscope will confirm the paralysis of the diaphragm. The diaphragm on the side operated upon will be found to lie in a higher position than on the other side and to be practically immobile during the phases of respiration. Very frequently a paradoxical motion will be seen, that is, during inspiration the paralyzed side will actually rise into the thoracic cavity to drop back again during expiration. It is not until several weeks or even months after the operation that the diaphragm assumes its final, most elevated position. In this case it rises from one and one-half to two interspaces higher than normal, reducing the thoracic cavity to the equivalent of about 400 to 500 cubic centimeters.

After the operation the patient may, within a few hours, return to his previous hospital régime. No pain will be experienced and there is no particular reason as a rule to keep the patient in bed or forbid eating. For hypersensitive patients a sedative may be required because of the skin incision, but this is usually not necessary. In fact, ordinarily, especially in those cases who have had paroxysms of coughing before operation, the patient will either have no discomfort whatsoever or will actually feel immediate relief. After the fourth or fifth day the intracuticular stitch may be removed and if the wound is closed, dressing may be dispensed with.

The benefits of operation can usually not be estimated for several months. In some cases of bronchiectasis, for example, which improve after phrenicectomy, the sputum at first may be even more copious than before and only gradually diminish. The same may apply to some cases of lung abscess. In other cases the improvement sets in early and the sputum and febrile reaction, if there is any, subsides almost as if by magic. In those cases of pulmonary tuberculosis in which phrenicectomy has been performed as an experimental procedure to test out the patient's tolerance before performing the operation of extrapleural-thoracoplasty, the results can usually be seen within a short time. If the tolerance is poor, an increase in the afternoon temperature, an increase in the number of tubercle bacilli found in the sputum, and often an aggravation in symptoms may be noted within a few days after the operation.

THE TANNIC ACID TREATMENT OF BURNS IN CHILDREN

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THE importance of having a satisfactory treatment for burns is at once apparent when we recognize the high mortality and the prolonged and deforming morbidity that accompanies this group of injuries. From a perusal of the surgical literature, it is plainly evident that almost up to the present time there has been no unanimity of opinion as to what constitutes the ideal or even the best treatment for burns. The number and variety of the methods that have been advocated from time to time tend to substantiate this fact.

In the treatment of burns, we have a complex situation in that several factors have to be controlled. The treatment must aim (1) to stop pain, (2) to prevent toxæmia, (3) to insure asepsis, (4) to prevent the loss of tissue fluids, and (5) to prevent contractures and scar formation. As these are the factors that govern the mortality or morbidity, it is evident that the value of a given treatment must be judged by its power to control these factors. Naturally, most of the methods that have been used have had some success in controlling one or more of these points; the ideal treatment is the one that is able to control all of them.

The treatment of burned patients usually consists of systemic and local measures. Practically all of the methods employed make use of the same systemic treatment. Briefly, this consists of morphine to relieve pain and shock, glucose and alkaline solutions to supply body fluids and combat toxæmia. In some instances blood transfusions have been given. Exsanguination followed by transfusion has been suggested. In the local treatment of burns the various methods employed fall essentially with these groups:

1. The biochemical or alkaline treatment. This consists of the application of a sterile, 10 per cent solution of bicarbonate of soda either as a continuous wet dressing or, if the burn is extensive, the patient may be kept in a warm soda bath for hours or days. This method is soothing and fairly efficient but it is rather cumbersome. However, in the burns of children this method is most valuable as a first aid home remedy. It is simple to apply and the necessary materials are found in every household.

2. The protective method or paraffine treatment. The principle underlying this method is that of protecting and splinting injured tissue, to stop pain and to permit restitution to take place. To accomplish this the burned area is sprayed or painted over with hot melted paraffine and then covered with cotton or gauze which is covered with paraffine. The original compound called "ambrine," which popularized this treatment, consisted of a mixture of:

Resorcin	1 part
Oil eucalyptus	2 parts
Olive oil	5 parts
Soft wax	25 parts
Hard wax	67 parts

Theoretically, this dressing should not require changing if the area is sterile, but usually the amount of discharge from the wound surface necessitates several changes of dressings.

3. Fixation methods. The principle on which this mode of treatment is based is that of healing a wound under a crust. For this purpose antiseptic drugs which have a desiccating and fixing action on the tissue cells are sprayed or painted over the burned area, or dressings, continually moistened with these drugs, are applied. To hasten drying and crust formation, evaporation is encouraged by open dressings.

The drugs that have been used in this method of treatment are absolute alcohol, aluminum acetate, picric acid, and tannic acid.

Dressings kept continuously saturated with absolute alcohol give remarkably good results. However, because of rapid evaporation, this method requires a great amount of attention and if the area involved is large the expense is considerable. Nevertheless, as it produces a minimum of scar tissue, alcohol is valuable in treating burns of the face.

Aluminum acetate consists of a 2 per cent alcoholic solution of aluminum acetate mixed with a 2 per cent solution of methylene blue in a preparation of 10 parts of the aluminum solution to 1 part of the methylene blue solution. This aluminum acetate solution is sprayed on the wound, a light gauze dressing is applied and drying is encouraged.

A one per cent solution of picric acid in 5 per cent alcohol is applied in the same manner as the aluminum solution. This method gives good results and it has been very popular. Its disadvantages are the yellow stain that it imparts to the linen that comes in contact with the dressing and, more important, the poisoning that may occur from drug absorption.

Fig. 1. Application of splints.

Fig. 2. Blankets placed to form tent over bed and electric lights suspended from roof of tent to supply warmth and thus help to dry the wound surfaces.

The use of tannic acid was introduced by Davison in 1925. His method consisted in the use of a 2.5 per cent freshly prepared solution of tannic acid in water applied on sterile gauze over the wound. The dressing is moistened every hour with this solution. The wound is inspected through a small opening in the dressing at the end of 12, 18, and 24 hours. As soon as the wound surface is well tanned as shown by a dark brown color, the dressing is well moistened and carefully removed. The dry tanned coagulum that now covers the wound is left exposed to the air. To protect the area from mechanical injury, bacterial invasion, or chilling, a sterile linen cage is placed over the wound area. If the burn is superficial, epithelization will proceed under the dry coagulum; if the burn is deeper the tanned crust will separate between the fourteenth and twentieth day leaving a clean granulating surface.

Davison based his treatment on the theory that the toxin present in the red cells was due to the absorption of the products of protein autolysis at the site of the burn. In order to limit this absorption he produced a coagulum of the devitalized tissues only, by the application of tannic acid. The dry crust thus produced prevented the loss of tissue fluids which leads to a lowering of the sodium chloride of the blood. He obtained in that way a marked lessening of the toxæmia.

In addition, the tannic acid applications produced a definite analgesia and did not affect the normal skin. In the burned area, islands of epidermis from hair follicles and skin glands are preserved. Sepsis is avoided by the dry coagulum which forms an unfavorable nidus for bacterial growth.

In my experience with this method in children, I have proceeded as follows:

Immediately on admission, the patient is given a dose of morphine sufficient to control pain. The skin about the burned area is carefully cleansed with benzine or ether and gross particles of dirt

Fig. 3. Showing the dry crust, smooth like a piece of leather, which completely seals the wound and is insensitive.

Fig. 4. In superficial burns the crust loosens at edge as epithelization progresses and the loosened portion can be cut away with scissors.

Fig. 5. Patient on whom 5 per cent tannic acid treatment had been used.

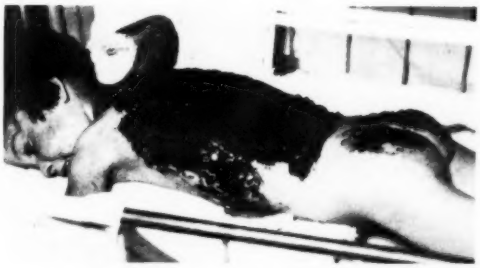

Fig. 6. Patient with extensive burns on back and about buttocks, showing the advantages of this treatment.

are removed with sterile instruments. A 5 per cent solution of tannic acid is then sprayed over the wound. This solution should be freshly prepared as it turns to gallic acid on standing. Without clothes or dressings of any kind, the child is placed in bed on a sterile sheet. Any necessary splints or suspension apparatus for the limbs are then applied (Fig. 1). Blankets are placed to form a tent over the bed with one or two electric lights suspended from the roof for warmth and drying purposes (Fig. 2). Fluids are forced by mouth or given by hypodermoclysis or proctoclysis. In the more severe cases glucose solutions or blood transfusions are given intravenously. Every half hour the wound area is sprayed with the tannic acid solution but no dressings are applied. After the first half hour the wound becomes painless and remains so. In from 15 to 24 hours depending on the depth of the burn, a dry brown crust, smooth like a piece of leather, has formed over the wound (Fig. 3). This heavy, dry crust completely seals the wound and is insensitive. The child is kept under the tent and no further local applications are made. At the end of 3 or 4 days, all evidences of toxæmia usually disappear. Locally, if the burn is superficial, the crust begins to loosen at the edge as epithelization goes on and the loosened portion can be cut away with a scissors (Fig. 4). In the deeper burns the crust usually loosens in from 2 to 3 weeks leaving a clean granulating surface which can be prepared for skin grafting by wet dressings of saline or Dakin's solution. If evidences of sepsis arise at any time, holes may be made in the crust for the application of Dakin's solution or the entire crust may be removed by softening it with vaseline. It has been found, however, that if wet dressings of boric acid are used, a rapid toxæmia arises that is frequently fatal.

I have altered the method of Davison in applying the tannic acid by omitting the use of gauze dressings. When the coagulum was produced under gauze, it was sometimes difficult to remove the dressing as the gauze tended to adhere to the wound in places. By using the spray no dressings are necessary.

The solution advised by Davison was a 2.5 per cent strength but he stated that a solution up to 5 per cent could be used. I have found that a 5 per cent solution produces a coagulum more rapidly and does not seem to affect the uninjured tissue. Also for burns about the face Davison suggested the use of a 5 per cent tannic acid ointment. I have tried this, but it did not seem to act as satisfactorily as the 5 per cent solution applied as a very fine spray (Fig. 5).

SUMMARY

I used this treatment in 24 cases in children with two deaths, both of which were due to pneumonia and occurred in infants about 10 months of age. In common with Gordon, Seeger, Fraser, McCullough, Beck, and Powers, I feel that this method is a real advance in the treatment of burns and more than any other method, it has reduced the mortality figure. Bancroft and Rogers have recently reported a mortality of 20 per cent in 114 cases. By the prevention of infection, scar formation is reduced to a minimum as skin grafting can be done very early if epithelization does not occur spontaneously.

The practical absence of pain by the analgesia of the tannic acid and the complete freedom from dressings is a joy, not only to these children but to the surgeon who has to look after them. In the rather frequent burns about the buttocks and genital region that are so difficult to dress and keep clean, the advantages of this method are very apparent (Fig. 6). There are no large weeping wounds, as the dry coagulum prevents the loss of body fluids. In the same way toxæmia is distinctly lessened by the coagulation of the devitalized tissue which prevents absorption of toxic products.

In conclusion, it would seem that by controlling all of the factors required in the treatment of burns, the tannic acid treatment where applicable is ideal. In addition, the treatment is inexpensive as tannic acid is cheap. The solution can be readily made by adding one half a teaspoonful of tannic acid powder to an ounce of water. As the powder keeps readily it should be placed in all emergency outfits. For obvious reasons, this treatment should be of decided value to industrial surgeons. Wherever possible, the tannic acid solution should be employed at the first treatment for we have found it is very difficult to secure a good coagulum and keep the burned area aseptic if some other form of treatment is used before the tannic acid is applied. I feel that here, as in many other places in surgery, it is the man who first sees the patient and applies the first treatment that determines the ultimate outcome in that particular case.

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PROLAPSE OF THE RECTUM IN CHILDREN

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PROLAPSE of the rectum is generally accepted as a descent, with or without protrusion, of one or all of the coats of the rectum. The variety usually encountered in children is the incomplete or partial prolapse. It is an exaggeration of the normal eversion of the mucous membrane which occurs at every bowel movement. Normally the loose connective tissue in the rectal wall stretches somewhat to facilitate the ejection of fæces and then contracts again. When this tissue is not normally elastic, the mucous membrane protrudes farther than normal and is not drawn back. Persistence of the partial prolapse drags upon the fibrous and elastic attachment of the mucous membrane to the muscular wall and eventually pulls the entire wall downward, thus producing a complete prolapse.

There are several predisposing causes. One of the commonest is relaxation of the sphincter and an absorption of the perirectal fatty cushions which normally surround the lower end of the rectum and anal canal. Todd has shown that the infantile rectum lies on a lower plane than do the other pelvic organs, which in their descent exert a downward pressure on the rectum. This anatomic arrangement, combined with the effect of the nearly vertical childish sacrum will account for many prolapses in children.

There are many exciting causes. Rickets, summer diarrhœa, dysentery, and other exhausting diseases, by reason of the weight loss and the lowering of general tissue tone which they produce, frequently initiate a prolapse. In diarrhœa, a reciprocal relation or a vicious cycle must be considered. Rather than diarrhœa causing prolapse, the latter condition may be the cause of the former. In fact there is reason for believing that prolapse is more frequently responsible for diarrhœa than diarrhœa is responsible for prolapse. Prolapse is especially likely to cause a persistence of diarrhœa when the mucous membrane is excoriated and inflamed. Most infants strain violently with bowel movements. Hard stools, polyps, phimosis, and diarrhœa may cause unusual straining efforts and precipitate a prolapse.

Many authors assign as the most prolific source of prolapse the practice of compelling children to sit on the stool until their bowels move. This is a well established habit in the modern household. It is a question whether or not a normal child, without predisposing causes, would develop prolapse from this practice.

In the beginning prolapse is associated with very few symptoms. An exaggeration of the protrusion of the mucous membrane occurs normally at stool. This protrusion gradually increases in size until it is perceptible and annoying. At first the prolapse is reduced spontaneously or recedes under gentle pressure. As the protru-

sion increases, the sphincter muscle grasps it more firmly, and reduction becomes increasingly difficult. The frequent protrusion gradually overstretches the sphincter, so that tonicity is markedly reduced. In view of this relaxed condition and a persistent peristalsis associated with irritation of the rectum incontinence often exists. The discharge of mucus and liquid stools frequently irritate the surrounding skin and cause pain or discomfort. Children with prolapse dread every bowel movement; postponement results in altered metabolism and constitutional disturbance.

The diagnosis of prolapse can be made easily. However, it is surprising to see how often prolapse is diagnosed as hæmorrhoids. The latter occur very rarely in children. Occasionally, a large polyp may present itself at the anus, and be confused with partial prolapse. Polyps are often seen in children. In the effort to expel them an actual prolapse may develop. A prolapse may be of any size from that of a walnut to that of an orange, and not infrequently protrudes 3 to 4 inches. The mother often states that the mass which protrudes looks like a small red apple. A prolapse apparently surrounds the anus without division into definite tumors. First the color is like normal mucous membrane. Later it becomes red with irritation, and sometimes purplish with congestion. When chronic, the surface is covered with patches and strings of mucus. The soft velvety feeling is lost, and the tissues feel thick and boggy; it becomes friable and is very easily torn.

The first consideration in the treatment of prolapse in children is to maintain the organ in its natural position, while the general constitutional condition and muscular tone are being restored to normal. Immediate treatment of prolapse is often necessary. If the prolapsed tissues have been exposed for a considerable time, there may be swelling and œdema. Gradual and continued pressure with hot compresses may frequently give comfort and at the same time reduce the mass.

An easy method of reduction is to cover the finger with a piece of toilet paper, introducing it into the lumen of the mass, forcing the finger carefully into the rectum, immediately withdrawing. The dry paper adheres to the mucous membrane, and releases the finger. The toilet paper softens and is expelled with the next bowel movement. The child should be kept upon its face for a short time thereafter.

When prolapse is the result of exhausting diseases as summer diarrhœa, dysentery, and rickets, one will obtain the best results by first combating these conditions. Cod liver oil, general tonic treatment, and a proper diet are important. Compresses for supporting a prolapse are not satisfactory. Pressure thus produced dilates and relaxes the sphincter, aggravating the condition. Frequently various types of rectal plugs and freak harnesses are used. They defeat their purpose by dilating the sphincter. Broad strips of adhesive passed anteriorly to anus and from one trochanter to the other so that they do not interfere with defæcation will serve well for temporary support. These can be changed every 10 to 12 days, without causing too much skin irritation. In addition, local applications, which stimulate contraction of the sphincter muscle and retraction of the prolapsed gut, should be made frequently. Cold water is one of the best of such applications.

To prevent the occurrence of prolapse during bowel movement, the child should be required to defæcate in the dorsal position into pads of cotton. These movements should be expedited and straining minimized by an enema administered in the proper position. It is important to keep the stools soft and the rectum lubricated. This is best accomplished by the administration of mineral oil and by giving an increased quantity of fruits, vegetables, and fluids. It is true that prolapse in children can often be cured by careful study of the patient, the regulation of the diet, the removal of sources of irritation if any exist, the control of diarrhœa or constipation, the strapping of the buttocks, and the administration of cod liver oil or some other tonic. After apparent cure, careful and prolonged observation is necessary in the prevention of recurrence. Such management is laborious and often impracticable. Some cases do not yield to these conservative measures and demand more radical treatment.

For the treatment of prolapse which has not been relieved by palliative measures and medical treatment, many radical methods have been devised. Some of these are formidable operative procedures, such as partial or complete excision of the prolapsed tissues; excision of elliptical sections as in hæmorrhoidectomy; clamp and cautery; suturing through the rectum and around the coccyx. Both Tuttle and Mummery have resorted to scarification between the rectum and the sacrum, with packing of the ischiorectal fossæ. Thiersch passed a silver wire subcutaneously around the anus. Plenz inserted fascial strips taken from the thigh around the anus. The literature contains many reports of poor results from these radical procedures. Weber in Leipzig

reports recurrence of prolapse in 17 per cent of patients treated by colopexy and in 61 per cent treated by running a silver wire around the anus. Some report good results from the application of nitric acid, the actual cautery, and the injection of various irritating fluids, such as phenol, alcohol, and quinine and urea hydrochloride. Tuttle objected strenuously to the use of nitric acid, stating that the burns could not be controlled and produced deep sloughs and hæmorrhage, with resulting stricture. The difficulty with the injection of irritating fluids is that the extent of the inflammation in the submucosa cannot be controlled.

Findlay and Galbraith have reported treatment of 41 children by injection of absolute alcohol into the submucosa. They report 90 per cent of their cases cured, although in several cases it was necessary to repeat the treatment once or twice. A general anæsthetic was used in all treatments.

Following the publication of Van Buren's book approximately 50 years ago, linear cauterization has been used sporadically by different men in different parts of the world. Cauterization sets up an inflammatory reaction in the submucous tissues directly beneath the line of application. In the organization of these inflammatory areas, there is a development of fibrous tissue which firmly binds all coats of the rectal wall to its surrounding structures. A search of the literature did not reveal any series of more than a few cases in which this treatment was employed. Why this excellent method has never come into general use is not obvious to the writer.

In 1920, at the Childrens Hospital of Michigan, an 8-year-old girl, who had been subjected to several operations for prolapse, came in with a recurrence. In the last operation, a wire suture had been inserted around the anal orifice. An abscess had developed and in addition to prolapse the child presented a fistula. The fistula was excised and linear cauterization was done. The result was perfect. Encouraged by the outcome of this difficult case, we have employed this treatment in 8 to 10 cases each year, this being about half the total number of prolapse cases observed in this clinic.

TECHNIQUE

The technique as used at the Childrens Hospital may be described as follows:

Under ether anæsthesia the rectal wall is brought out as far as possible with Pennington triangle forceps attached anteriorly, posteriorly, and laterally. The mucous membrane is carefully dried. Then with a narrow Paquelin cautery four linear longitudinal incisions are made through the mucous membrane extending up to but not into the anal canal. Care must be taken not to penetrate the rectal wall, especially anteriorly. The prolapsed tissues are then gently replaced. A rubber tube is encircled with a two-inch bandage forming a plug approximately 3 centimeters in diameter. This is well lubricated with an ointment made by mixing 2 drams of soda bicarbonate with 1 ounce of vaseline. This lubricated plug is inserted into the rectum and is kept firmly in position by adhesive plaster which is passed completely around the body at the level of the trochanters. If this precaution is not adopted, the severe straining of the child coming out of the anæsthetic will force the plug out, and the bowel will again protrude. When the plug is properly applied, the straining soon ceases and the child complains of little or no pain. The knees are firmly bound together with a bandage to prevent standing and spreading of the buttocks, which might release the tube. The plug is removed in 48 hours. By this time there has been an outpouring of inflammatory products into the submucosa producing a swelling which in itself prevents extrusion of the rectum. It is remarkable but true that these children do not require postoperative opiates. There is apparently very little discomfort following the operation. After the tube has been removed, a small soda enema is given.

The child is usually able to leave the hospital in one week, and the mother is instructed to see that all bowel movements for 3 weeks are passed in the dorsal position. Small doses of mineral oil are given daily. The patient is returned for examination in one month.

Sixty-two children ranging in age from 3 months to 11 years have been treated in this fashion. In 12 cases (19 per cent) the prolapse had been present for less than 1 month; in 18 (29 per cent) for more than 1 year; and in 1 case (1.6 per cent) for 11 years. This last patient frequently was forced to leave school or play for reduction of the prolapse.

One child, 3 months old, not included in this series, presented a history of prolapse for a period of 4 days before admission. Examination disclosed a mass 6 inches long retracted toward the sacrum. Efforts to reduce the mass were futile. The child lived 30 hours after admission to the hospital. An autopsy revealed that the rectum, sigmoid, descending colon, and the left half of the transverse colon had prolapsed. A loop of jejunum 15 centimeters in length was twisted into the sac formed by the prolapse of the sigmoid.

This case demonstrates that a simple prolapse if neglected may be followed by very serious developments. It was necessary to repeat the cauterization on just one patient. This was probably due to inadequate cauterization. In the remaining cases only one treatment was necessary to obtain a cure, and to date there have been no recurrences.

In 38 (61 per cent) of these cases, the condition 2 years after the operation was determined. Frequent rectal examinations have not demonstrated any stenosis, scars, indurations, or other untoward results. Operation has been avoided when a child had fever or respiratory infection of any type. There were no cases of postanæsthetic chest infection. The results which have been obtained in this series of cases justify the presentation of this work.

CORRESPONDENCE

SPINAL ANÆSTHESIA IN THE TREATMENT OF PARALYTIC ILEUS—*A Correction*

To the Editor: It has been called to my attention that there is an error present in my paper entitled "Spinal Anæsthesia in the Treatment of Paralytic Ileus," which was published in the December, 1928, issue of SURGERY, GYNECOLOGY AND OBSTETRICS. Through an oversight on my part the amount of novocaine solution used has been given as 0.3 gram instead of *0.1* gram.

W. E. STUDDIFORD, M.D.
New York

EIGHTH CONGRESS OF THE SOCIÉTÉ INTERNATIONALE DE CHIRURGIE

The Eighth Congress of the Société Internationale de Chirurgie will meet in Warsaw, Poland, July 23 to 26, 1929. A most interesting program, which will include speakers from many countries of the world, is being prepared.

Further information and preliminary announcement may be obtained by addressing Dr. L. Mayer, secretary general of the society, 72, Rue de la Loi, Brussels, Belgium.

EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

FRANKLIN H. MARTIN, M.D. . . . . Managing Editor
ALLEN B. KANAVEL, M.D. . . . . Associate Editor

WILLIAM J. MAYO, M.D. . . . . Chief of Editorial Staff

FEBRUARY, 1929

BLOOD CHLORIDE DEPLETION

AN appreciation of the dangers of blood chloride depletion is of importance in the treatment of many surgical conditions.

In the past, surgeons have stood by after a successful operation for the relief of intestinal obstruction, and watched the patient die from what was called toxæmia, but what really was a condition known as alkalosis due to blood chloride depletion. Whether such depletion is due to a combination of chloride with the toxin produced or to an excretion of chloride into the intestinal lumen or failure of absorption due to loss of hydrochloric acid by vomiting is an unsolved question. Even if the blood chloride depletion is a result rather than a cause of the toxic postoperative condition, one must feel after observing these cases that the diminution of blood chloride is an indication of the severity of the condition. Our attention was first called to this condition some years ago when we reported a series of cases of uraemia following gastro-enterostomy. We know now that the blood chloride depletion was the important factor and that the condition was one of alkalosis. Our subsequent impression was that the chloride depletion was due to loss of hydrochloric acid by vomiting, but subsequent laboratory work has proved this view to be fallacious. The exact mechanism responsible for this condition is still a fertile field for investigation.

Many surgical conditions are characterized by marked chloride loss: the various fistulæ, gastric and duodenal, and the obstructions, functional and mechanical, of the stomach and bowel. The successful pre-operative and postoperative treatment of such cases demands among other things and not the least important a knowledge of the condition of the blood chlorides. For many years surgeons have been giving salt solution empirically to replace the fluid loss, when the important thing was not only the fluid loss but the chloride depletion.

The laboratory tests necessary for such knowledge are well within the range of the ordinary laboratory and should not be neglected. Without such knowledge one runs the risk of not fully supplying the patient's needs.

Normally the blood contains between 500 and 600 milligrams for each 100 cubic centimeters of blood. Under the conditions present in intestinal or gastric obstruction, the blood chloride falls as low as 300 milligrams. This loss turns the tide of neutrality of the blood toward alkalinity with a lowering of the blood chloride, a rise of the carbon dioxide combining power, and an increase of the non-protein nitrogen.

Credit must be given to Haden and Orr for bringing this condition of alkalosis to the

attention of the medical profession. It has been found that, whereas in former years great stress was laid on the condition known as acidosis, this change, aside from the surgical diabetic and nephritic cases, seldom takes place. The condition known as alkalosis is more common than acidosis and just as serious in its outcome. The symptoms of both are very similar; hence the importance of differentiation, because treatment for acidosis would be very dangerous for the patient with alkalosis. Tests for the blood chloride as well as non-protein nitrogen serve to differentiate the condition.

Treatment for alkalosis is comparatively simple. Salt solution in 3 per cent dilution intravenously as well as subcutaneously can be given in such amounts as to raise the blood chloride to normal. We have not found in our experience much change in the blood chloride by rectal administration of saline solution. In the giving of this solution it is better to give too much rather than too little. As high as 6 liters can be given in 24 hours without harm.

Attention to this condition in the preoperative and postoperative care of gastric and intestinal obstruction cases will result in better surgical results. W. J. TUCKER.

FIVE ESSENTIAL FACTORS IN THE TREATMENT OF ACUTE INTESTINAL OBSTRUCTION

ACUTE intestinal obstruction cannot be treated logically unless the following factors are taken into consideration and their relative importance properly evaluated in each patient: removal of the mechanical obstruction; drainage of the obstructed intestine; relief of toxæmia; relief of dehydration; and prevention of starvation.

It is obvious that a cure in intestinal obstruction cannot be obtained without removal of the obstruction. Just when an effort to release the obstruction by operation should be attempted is, in some cases, worthy of careful consideration. In the very early cases in which operation may be done before the patient is toxic, the obstruction can be relieved with comparative safety. If, however, the patient is much dehydrated and toxic, preoperative treatment with water and salt is imperative. The surgeon must then choose carefully between an operation to remove the obstruction and a temporary enterostomy to drain the obstructed gut.

Unquestionably, in the extremely toxic patient with obstruction of the small intestine, enterostomy frequently gives relief. Whether the enterostomy should be an ileostomy or a high jejunostomy may be a question worth considering in the light of recent results obtained by experimental drainage of the upper jejunum. Dogs die very quickly with upper jejunal drainage and the blood chemical changes are similar to those found in high intestinal obstruction. Walters and Bollman have recently called attention to the serious toxæmia which develops from duodenal fistula. It is entirely possible that prolonged high jejunal drainage may be harmful. In spite of many recommendations for high drainage of the jejunum, it seems safer to recommend the drainage of the distended small intestine at a point where it is most easily accessible. If this is done in conjunction with the treatment which will be outlined later, success may be expected in a large percentage of cases. In those cases with enormously distended gut and with complete loss of peristalsis, failure of complete drainage may be expected, since in such cases it is likely that only a small segment of the bowel will be drained. The non-operative drainage of the upper intestine and stomach with a duodenal tube may prove valuable but can

hardly be expected to render the same service as drainage of the gut nearer the obstruction.

The toxæmia developing in obstruction of the small bowel should receive careful treatment. It seems clear that the administration of sodium chloride has a tendency to relieve the toxic symptoms. Since a definite reduction in the blood chlorides exists in a patient ill with obstruction of the small intestine, it is quite logical to supply this salt in a quantity sufficient to restore the chlorides to normal. Abundant proof has now been presented that sodium chloride has a definite therapeutic value in this condition and has a definite tendency to restore to normal the abnormal chemical changes found in the blood. The conclusion may then be drawn that sodium chloride has a definite effect upon, and is of value in, combating toxæmia.

The observation of Hughson and Scarff that a hypertonic solution of sodium chloride stimulates peristalsis must be taken into consideration. It is quite possible that sodium chloride increases the tone of the bowel muscle and aids in overcoming or inhibiting the distention and paralysis. In extremely toxic patients, physiologic sodium chloride solution does not contain sufficient salt to restore the body chlorides rapidly. The intake of salt may be rapidly increased by giving a 2 per cent solution by hypodermoclysis and a 3 or 5 per cent solution intravenously. The solution should be given slowly so as to prevent pain and possible sloughing as a result of the first method and to prevent damage to the blood elements as a result of the second method.

The relief of dehydration must go hand-in-hand with the relief of the toxæmia. The chemical processes of the body are not expected to function properly without a sufficient supply of water. In patients who are very ill with intestinal obstruction, 4 to 6 liters should be given every 24 hours subcutaneously, intravenously, and per rectum, until the patient is beyond the danger point. Crile's dictum to "water early; water continuously; water late" should ever be kept in mind. The condition cannot be treated logically without maintaining water balance.

Supplying food is of less importance than supplying water and sodium chloride. Its importance should, however, be recognized, especially if the patient has been ill for several days. The reason for the administration of food needs no discussion. Since patients with intestinal obstruction cannot take food by mouth, it is best given as glucose intravenously. It has been estimated that man can utilize 0.8 to 0.9 grams of glucose per kilogram of body weight per hour for an indefinite period. Insulin may be given to aid in the utilization of glucose. By giving glucose very slowly in solutions of 10 to 25 per cent, much food can be supplied as the dehydration is treated. The average patient weighing 70 kilograms could, according to this estimate, tolerate an average of 60 grams of glucose per hour without its overflow in the urine. This quantity of sugar is equivalent to approximately 240 calories. It is readily seen that a substantial quantity of food may be given a patient as glucose during a 24 hour period. By the use of a combined 1 per cent sodium chloride and 10 per cent glucose solution, both forms of treatment may be given together advantageously.

The five essential points in connection with the treatment may be summarized as follows:

1. Operation to release an acute intestinal obstruction should never be attempted without preliminary treatment when a patient is very toxic and dehydrated.

2. In a large percentage of cases of intestinal obstruction with toxic symptoms, enterostomy should be substituted as a temporary procedure before an exploratory operation is

attempted to find and relieve the obstruction.

3. No surgery should be done in toxic cases before the toxæmia had been treated by the administration of sodium chloride.

4. Dehydration and toxæmia are treated simultaneously by the giving of large quantities of sodium chloride solution.

5. As long as nourishment cannot be given by mouth, glucose solution should be given daily to furnish food. THOMAS G. ORR.

PAN-PACIFIC SURGICAL CONGRESS

THE first international surgical congress to be held in the Pacific has been called by the Pan-Pacific Union of Honolulu and will meet there August 14 to 24, 1929.

The United States government has invited, through the Department of State, twenty countries to participate, representing thirty separate states, exclusive of the states and territories of the United States, all of which border on the Pacific Ocean. The Province of British Columbia will represent Canada and Washington, Oregon, and California will represent the United States.

The United States will also be officially represented by delegates from the Army, Navy, Philippines, Canal Zone, Alaska, universities and surgical societies of the Pacific Coast States, and the American College of Surgeons. Great Britain will have delegates from Canada, Australia, New Zealand, Fiji, Federated Malay States, Straits Settlement, British Samoa, Hongkong, and India. This shows very strikingly the extent of Anglo-Saxon influence in the Pacific region.

English will be the official language of the Congress, but the transactions will be fully translated and published by the *Pan-Pacific Union Journal and Press*.

There can be no question as to the value of this meeting from an international viewpoint. Every effort is now being put forth to develop a feeling of amity and mutual understanding between the peoples of the Pacific. Honolulu is the "crossroads" geographically for all the merchant lanes across the Pacific and is a happy choice for such a meeting.

The Pacific Coast surgeons who have the honor of presenting American surgical ideals and technique have a great opportunity at this time to carry forward the ideals of American surgery. In choosing the men to represent American surgery, the committee has been limited to those surgeons who, by affiliation with the large surgical societies, have been given approval by their associates and co-workers. The scientific exhibits will be entrusted to the three large medical colleges on the Pacific Coast.

Hospital standardization, covering every phase of hospital activities from the selection of a site to the completed institution operating as an efficient, economical unit to render prompt service to the patient, will be offered as America's greatest contribution to the development of surgery. This will be presented by the American College of Surgeons, at the request of the surgeons of Hawaii.

With such a program, representing American teaching institutions, surgeons, and hospitals, the surgery of America will be well presented to the visiting surgeons from the Orient, South America, Australia, and North America.

In behalf of the officers of the Pan-Pacific Surgical Conference, may I extend to the readers of this Journal a cordial invitation to be present at the forthcoming Conference to be held in Honolulu, August 14 to 24, 1929. Full particulars regarding the meeting may be had by addressing George W. Swift, M. D., general chairman, Pacific Coast States and British Columbia, Seattle. Washington.

GEORGE W. SWIFT.

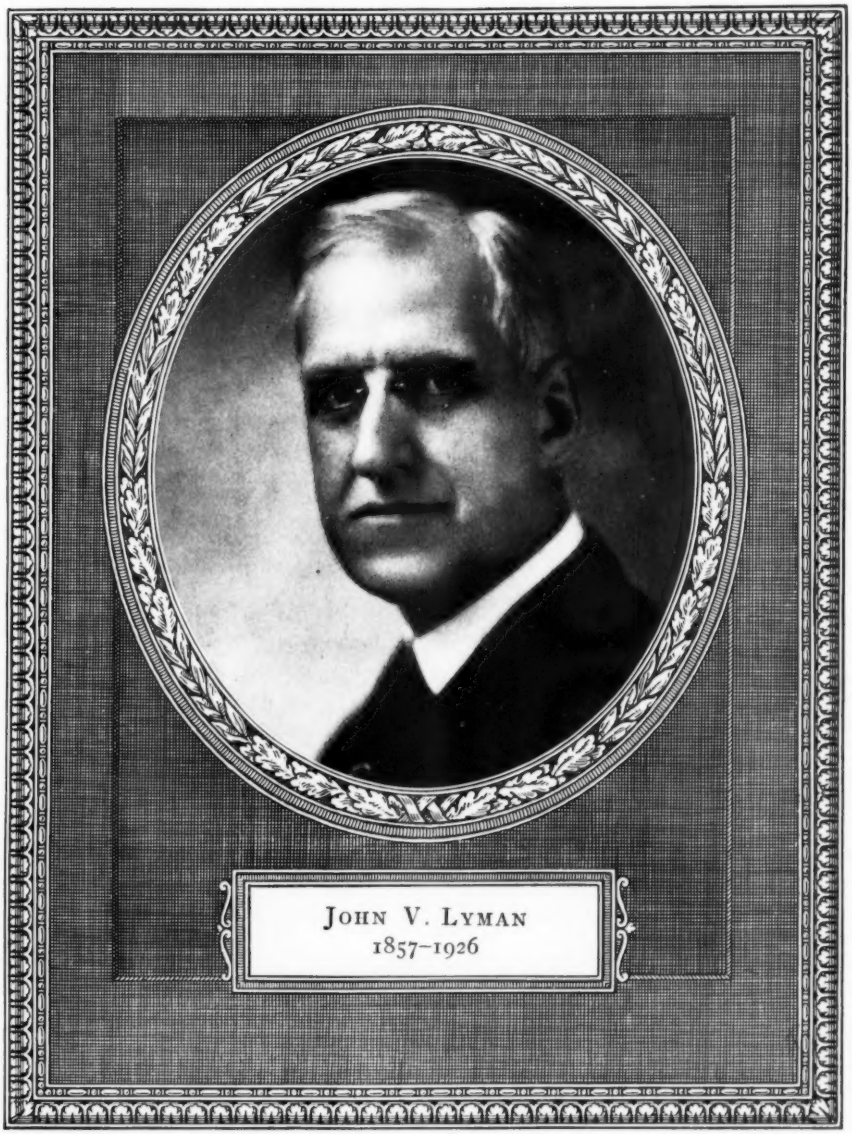
MASTER SURGEONS OF AMERICA

JOHN VAN REED LYMAN

JOHN Van Reed Lyman was a man who, first by nature and later through environment, was not destined to occupy the lime-light in the popular sense of the term. The halo which ultimately illumined this humane, gentle, manly, honest, scientific and sacrificial man was not of the high-powered, far-carrying type. The radius over which it cast its rays was comparatively short. These rays were, however, of a compensating intensity.

The lineage of Dr. Lyman can be traced back to Thomas Lyman, who lived in England in 1275. His first ancestor to reach America's shores was Richard Lyman, who migrated from Norton, Mandeville, Parish of Onger, Essex County, England, in 1631, and located at Charleston, Massachusetts. Twenty-six members of the fifth and sixth generations fought for our independence in the Revolutionary War. The generations in line of descent from Richard were John, Moses I, Moses II, Elias, Timothy I, Timothy II, and Timothy III, who was the grandfather of Dr. Lyman. He married Experience Bardwell and resided at Chester, Massachusetts. He died at fifty-two. Timothy IV, Dr. Lyman's father, was born August 28, 1819, graduated from Amherst College in 1844 and was ordained in the Congregational ministry in 1850. For fifteen years he was engaged in missionary work in the south and west. He was pastor in Killingworth, Connecticut, from 1866 to 1869 and died at Bar Harbor, Maine, at the age of 67. He married Valeria Van Reed Rhinehart June 15, 1854. Three sons were born, William Bardwell, who graduated from Rush Medical College in 1880, became prominent in his profession in the practice of medicine at Eau Claire, Wisconsin, and is now in practice in Boise, Idaho; Timothy, now practicing in Sacramento, California; and John Van Reed, who is the subject of this sketch.

Dr. John Van Reed Lyman was born in North Pepin, Wisconsin, January 13, 1857, received his academic education at Fort Madison, Iowa, where he graduated in 1873. He engaged in mercantile pursuits until 1876, when he began the study of medicine and later was appointed hospital steward in the penitentiary, where he enjoyed rare clinical advantages. In 1877 he attended the St. Louis Medical College and the following two years he studied at Rush Medical College, from which he was graduated in 1880, obviously better prepared than were most of the medical graduates of that period. He at once located in Eau Claire,



JOHN V. LYMAN
1857–1926

Wisconsin, a thriving lumber town, and there continued to practice medicine until his death, which occurred in a hospital in Wauwatosa, Wisconsin, on March 31, 1926.

In 1881 he married Maud Keplar and to them were born two children, Valeria (deceased) and John Van Reed, Jr.

On August 27, 1909, Dr. Lyman married Harriet Sylvister, who, with a son, Richard, now fifteen years old, survives him.

As stated above, the characteristics which have been the means of placing the name of Dr. Lyman upon this renowned list are not the usual variety, but are, for the most part, of a more or less personal nature. His professional life is vividly illuminative of certain phases of the practice of medicine. It illustrates so well the unheralded heroism so often associated with it; it signifies so perfectly the quality of service, the development of which the practice of medicine offers; it shows so well wherein true *greatness* so often lies; and demonstrates so conclusively that, even in a field which is restricted in the commonly accepted sense of the term, as was his, the highest ideals in medicine may be reached, and that opportunities, if taken advantage of, may serve to place one of our humble calling upon a pinnacle second to none.

To recite a history of the professional life of Dr. Lyman is but to recount an ensemble of activities which can best be encompassed by the term *service*. Success and misfortunes were intimately blended with his career to an unusual degree. He accepted the former with unwonted modesty, the latter with admirable fortitude.

He was a giant in stature and endowed with an extraordinary capacity for both physical and mental action. His splendid physique, his handsome, benevolent face, which was so evidently an index to the many fine qualities with which he was gifted—sincerity, honesty, sympathy, broad intelligence, and sound judgment—engendered confidence in all who knew him. These attributes at once brought him a large clientele, the care of which taxed his strength, unusual though it was, to the utmost through his professional life. He could not refuse a summons from a patient. Regardless of the distance or the hour "Doctor John" always responded. In the early days many patients were attended and operated upon in their homes many miles from Eau Claire. Even in the later years Dr. Lyman covered a large territory, generally by automobile, caring for those families who, through all the years, had depended upon him for succor.

Many years ago he developed a duodenal ulcer, which by causing him great distress and a number of hæmorrhages rendered the performance of his duties more difficult. Upon three different occasions he was forced to relinquish his practice for protracted periods and upon each occasion the esteem in which he was held was evidenced by an even larger volume of work presenting when he pluckily returned to the harness.

Only one factor was allowed to interfere with the constant care Dr. Lyman lavished upon his patients. This was his most assiduous attendance at the various medical meetings throughout this country and even abroad. As an example of his practice along this line, the writer, who as a boy had known Dr. Lyman, need only relate that, while the latter was a student at Rush Medical College, Dr. Lyman could be seen in the front row at the clinic of Dr. Nicholas Senn each Thursday afternoon. This was over twenty-five years ago. How often does one see such an example followed by surgeons of the present epoch in an effort to keep abreast of the times? Small wonder that he became an outstanding figure in his section of the country and that not only the laity but the profession as well looked to him for guidance.

The laity and the medical profession of Wisconsin felt his influence to a marked degree. His labors in improving the condition of the local hospitals and in rallying the public to their support are recognized by everyone in the section in which he practiced. All medical organizations received his hearty support, and his sound judgment and kindly, yet forceful, demeanor when in the chief office or on important committees were often the means whereby a harmonious rather than chaotic, a strong and vigorous rather than a weak and vascillating organization went upon its way.

He had been president of the local societies, including the County and State, and was, at the time of his death, president of the Interstate Post-Graduate Assembly. As a member of the Board of Governors of this organization and its predecessor—the Tri-State—his counsels unquestionably had much to do with its ultimate success as he gave his time, experience, and energy without stint to its upbuilding. The disheartening fact that his final illness prevented him from acting in the capacity of presiding officer of this organization, which he had served so long efficiently and faithfully, was a source of sorrow to all of its members.

About one year before Dr. Lyman's death he sustained a fracture of the femur while driving his automobile to attend a meeting of the officers of the Interstate Post-Graduate Assembly. After a prolonged convalescence he sustained a refracture. Long confinement and secondary anæmia from recurrent hæmorrhages from his ulcer undermined his health to such an extent that he entered a Wisconsin hospital and after undergoing a severe stomach operation, from which he recovered, he developed broncho-pneumonia, which caused his death at the age of sixty-nine.

The universal esteem in which he was held, the imprint of his acts of benevolence, his scientific achievements, the fact that he had, during his forty-five years of practice, acted in the capacity of family physician and in later years, "family surgeon" (a sobriquet which was not infrequently employed in describing him), his unique standing with the laity which made it possible for him to mold public

sentiment in favor of things medical, and the splendid example he set by invariably meeting adversity without complaint, make mere words seem futile in an attempt to elucidate the manner in which "Doctor John" so completely fulfilled his destiny. Few of those who have gone before have measured up better than he. His life's work is a splendid example for everyone and there are few who have been so fortunate as to have so profoundly and beneficially influenced those with whom they came in contact as Dr. John Van Reed Lyman. The medical profession might well be proud could it number among its members more men of his type.

ROBERT EMMETT FARR.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

ALFRED BROWN, M.D., F.A.C.S., OMAHA, NEBRASKA

THE "AD ALMANSOREM" OF RHAZES

THOUGHTLESS utilitarianism commits crimes against art and culture which can be classified only as atrocities. And yet these crimes lend zest to the quest of the collector, for even though the object, when found, may be imperfect and mutilated, yet the thrill of discovery blots out for the time the memory of the atrocity committed in the distant past. The pages of manuscript illustrated here are an example of one of these literary crimes.

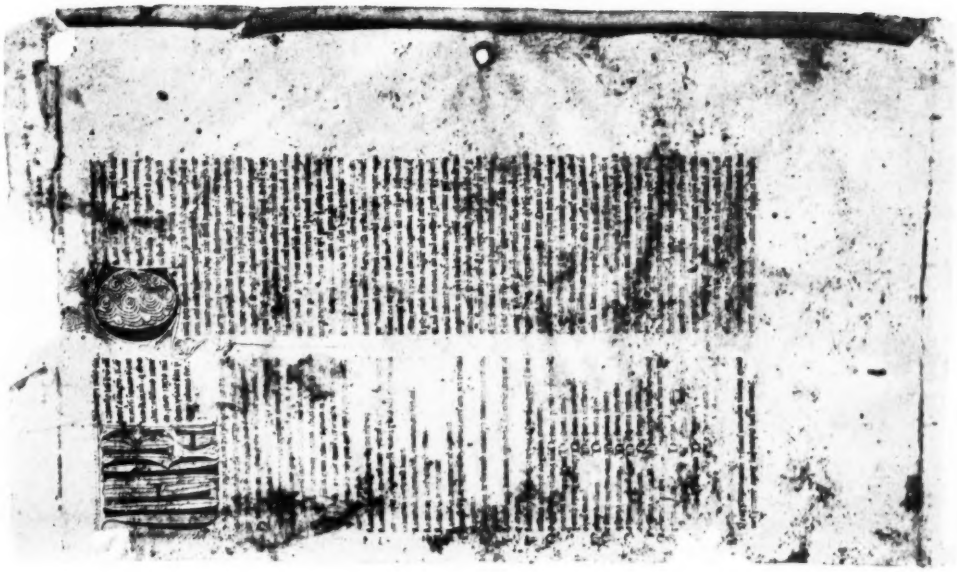
For centuries they served the purpose of covering a book printed and bound in the sixteenth century. Four centuries later the book was taken apart for rebinding by my friend Mr. J. Christian Bay. On the reverse of the vellum covering the writing was found and the pages were sent to me for identification and placement in their proper niche if such was possible. Fortunately the task was not an extremely difficult one, else my powers would not have availed. The manuscript is in great part legible and written in passably easy Latin and by a lucky chance the page headed by the beautifully illuminated letters proved to be the first page of a book and I read: "The words of Abubetri razis son of Zacharie. The Book begins: which by him was called Al mansor." Then followed another search and a year or so later, after much reading of catalogues, there arrived a book whose colophon reads: "This work is ended, printed at Venice by Jacobus Pencius de Leucho in the year of our Lord 1508, on the 8th day of March" and the first book in the volume is the Latin translation of *Liber Rasis ad almansorem* (The Book of Rhazes to the Caliph Almansor), which contains a compendium of the medicine and surgery of this Arabian Galen of the ninth and tenth centuries. The identification is now complete; for, save for a word or phrase here and there, the manuscript and corresponding parts of the printed book are the same. The first page of the book is represented by the leaf with the illuminated letters and the other leaf contains part of the ninth and tenth pages of the printed volume.

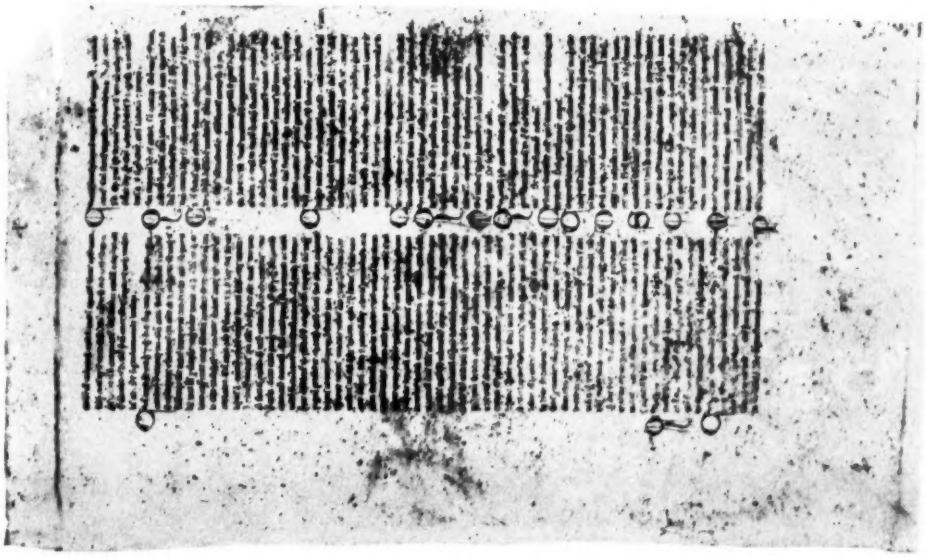
The translation is that of Gerhardus of Cremona who was born in 1114 and devoted a long life of seventy-three years to the translation of the Arabian medical texts into Latin, among others this work of Rhazes. The handwriting of the manuscript is that of the twelfth or thirteenth century and it was probably one of the copies made for use by the physicians of the day. But what of the other pages? Can we not imagine a printer and binder of the sixteenth century and one none too good, for the book was of no special import, tearing apart this beautiful folio volume in order to make covers for his mediocre books and thus scattering to the four winds a priceless fragment of world history? But it has always been so. The mind's eye sees a New England Puritan of the second or third generation with a large can of white paint and a whitewash brush smearing the beautiful mahogany surface of a Sheraton table so it will look nice and white and so fit into a spotless and shining kitchen, blissfully unconscious the while that with each stroke of his brush he commits a crime compared to which grand larceny is a mere pecadillo. In this case a later furniture finisher will carefully scrape away the paint and bring back the lustrous sheen to the surface of the old mahogany but, to our leaves of vellum, time and the bookworm have wrought havoc that no restoration can remove and they must remain as they are to the end of time, imperfect fragments of what was once a noble book.

The author of this book, Rhazes, became the foremost of the physicians of the early Arabian School. Until he was thirty years of age he was known only as a famous bard and player on the cithera, though he had obtained a good education in philosophy. Then he decided to study medicine and went to the University of Baghdad which had been founded in the early part of the eighth century and was eclipsing the school at Jondisapur. He left the University to return to his birthplace, the city of Rai, and undertook the task of organizing its hospitals. Once more he returned to Baghdad, this time as the director of its great hospital, and apparently as head of the medical department for he is believed to have drawn many students to Baghdad because of his great ability as a teacher.

During his long life—he probably lived to be over eighty—he traveled much. He visited Jerusalem, Egypt, Syria, Persia and went as far as Spain where he studied the medicine of the Western Caliphate; but in spite of his great vogue as physician and surgeon he died in blindness and in poverty.

In the main his work follows that of the Byzantine physicians, principally Paul of Aegina. He did some operative surgery, following this master. He is known largely for his short and pithy sayings, one of which is "Truth and certainty in medicine is an aim which is not to be attained: and the healing art as is described in books, is far inferior to the practical experience of a skillful and thoughtful physician."





UNIV. OF MICH.

REVIEWS OF NEW BOOKS

GERMAN publishers are putting forth at the present time numerous books on cancer. Two of the latest of these are *Mutationstheorie der Geschwulst-Entstehung*[1] by Dr. Med. K. H. Bauer, and *Ueber das Problem der Boesartigen Geschwuelste*[2] by Professor Dr. Lothar Heidenhain.

Professor Bauer's book is a small brochure of 72 pages and the thesis may be stated briefly as follows. Just as new species may result from mutations due to some permanent and transmissible alteration in the genes of the germ cells, so tumors may result from mutations due to permanent and transmissible alterations in the genes of somatic cells. Professor Bauer first presents a brief statement of the theory of mutations and then discusses the occurrence of mutations in germ cells and somatic cells. As examples of the latter he cites "localized albinism" (leucoderma), solitary exostoses, etc., which he believes are due to sudden alterations in the genes of one or more cells in a localized part of the body. These continue to reproduce cells with similar altered characteristics. Local alterations in genes and any resulting local changes in cells have certain definite characteristics; they occur singly, they are neither inherited nor inheritable, and they are morphologically identical with corresponding general forms.

This general idea is then applied to the origin of tumors in which the alteration in the genes is permanent and irreversible. Bauer insists that the division of tumors into benign and malignant growths is not scientific or practical and is not based on pathologico-anatomical or on clinical grounds. He applies the mutation theory to the etiology of tumors. Exogenous factors such as non-specific irritants induce tumors only when they cause cell mutations, that is, when they alter the genes or the chromosomes. Endogenous factors (which are not mentioned specifically) affect the cells of an organ or system in such a manner as to render them more susceptible to external irritants. Bauer insists that there is no "cancer heredity" in the scientific sense, that is, no transfer of the disease itself by way of a "mendelnde" gene. It is a matter rather of inheritance of "tissue inferiority" which actively favors the origin of tumors in the presence of added exogenous factors.

Professor Bauer's brochure is a closely reasoned thesis based largely upon theoretical considerations. He quotes Schwarz to the effect that "the gene is a hypothetical assumption" and Bauer's whole thesis is founded upon the alleged presence of genes in somatic cells and the transmissible alterations which may take place in them. Much of his reasoning is from analogy—always a dangerous method—such as alleged similarities between genes and atoms and electrons. The work is therefore not wholly convincing, but it does suggest a line of investigation into the origin of tumors which might be followed by expert geneticists possessing a greater knowledge of the fundamental problems involved than a professor of surgery could be expected to possess.

Professor Heidenhain, also a surgeon, has produced a more pretentious book of 153 pages, measuring 13 by 20 inches and containing 141 illustrations, chiefly photomicrographs.

These two volumes present many sharp contrasts. Bauer develops his conception of the etiology of tumors on the basis of the mutation theory of heredity. Heidenhain, on the other hand, is convinced of the infectious nature of the cause of tumors. He insists that the origin of malignant neoplasms is not purely a problem of cell growth. His starting point appears to have been the experiments of Keysser who injected 100 mice with material from 4 malignant human tumors, and after intervals of from 7 to 13 months found tumors in 4. However, 4 per cent is not a very high incidence of tumors in mice unless one is quite certain of the background of heredity in the stock of mice used.

Heidenhain developed the working hypothesis that means can be found for so destroying human cancer cells by lysis that the supposed cancer-causing agent will not be destroyed. This product of lysis of cancer cells when injected into animals is to be expected to produce tumors. According to the place in the body where the cancer-causing agent acts, epithelial or connective tissue tumors, carcinomata or sarcomata will originate, thus furnishing an etiological unity. Heidenhain prepared autolysates of various malignant tumors and injected these into mice, and claims to have induced tumors in 5.2 per cent of the animals. He found no difference in the effects of the autolysate of aseptic and infected tumors and concludes that bacterial infection is not concerned in the causation of tumors alleged to result from inoculation.

The entire book is a profusely illustrated presentation of evidence which is presumed to favor the acceptability of the author's working hypothesis, but the labored discussion is far from convincing. Heidenhain reports positive results (tumors) in 83 (5.2 per cent) of 1601 injected mice, some of which had multiple tumors. He cites statistics from Miss Slye's publications to the effect that she found spontaneous tumors in 1.25 per cent of her tumor strains of mice. Because neoplasms occur spontaneously with relatively great frequency in mice, these are not satisfactory animals on which to base any claim as to the infectious nature of tumors. Heidenhain attempted to exclude cancerous heredity in his mice by the testimony of the breeder from

[1] MUTATIONSTHEORIE DER GESCHWULST-ENTSTEHUNG; UEBERGANG VON KORPERZELLEN IN GESCHWULSTZELLEN DURCH GEN-AENDERUNG. By Dr. Med. K. H. Bauer. Berlin: Julius Springer, 1928.

[2] UEBER DAS PROBLEM DER BOESARTIGEN GESCHWUELSTE; EINE EXPERIMENTELLE UND THEORETISCHE UNTERSUCHUNG. By Professor Dr. Lothar Heidenhain. Berlin: Julius Springer, 1928.

whom he obtained them. This evidence is set down at some length after the manner of a court report but does not establish the case "beyond reasonable doubt." Most of the tumors in these mice developed at a distance from the site of the injection. Furthermore the type of tumors produced was not always similar to the injected material. The photomicrographs reveal a great variety of tumors in the series of mice. The reviewer has seen in sections from the Slye strains of mice spontaneous tumors that would duplicate almost every type described and pictured by Heidenhain. Thus another attempt to establish the infectious nature of cancer falls short of accomplishment. J. P. SIMONDS.

PELOUZE, in his recent publication, *Gonococcal Urethritis in the Male*,[1] tells a true story of the disease in a concise manner. For educational purposes, he urges the use of the term "gonorrhœa."

As most writers have done, Pelouze stresses the importance of the gram stain for differentiating organisms. With calf's brain agar for a medium the gonococcus is readily grown. Little attention is paid to the time-old idea that the gonococcus cannot withstand heat or cold. The so-called strains of gonococcus only represent differences in the resistance of the patients.

If it is kept in mind that gonococci penetrate deep into the submucous layers, the craze for quick germicides will soon die out. That a high body temperature *per se* affects the gonococcus is doubtful, but good probably comes from febrile tissue change.

A profuse urethral discharge subtracts from the supply in the body at large of the particular substances that stimulate the real curative processes. Any cure of gonorrhœa is due to the body's defensive processes and any bland local treatment that is properly carried out is of help. Phagocytosis is probably a detriment in that it takes away antigen for stimulating antibody formation. Antibody formation is most easily stopped by alcohol and sexual stimulation.

The author has never seen a case of extra sexual gonorrhœa in the male. The usual incubation period is put at from 3 to 5 days but may vary from 3 to 40 days. The two-glass urine test is most valuable for locating and following the course of the infection. Whether the gonococcus is intracellular or extracellular, has little significance, according to the author.

The clinical course of gonorrhœa is constant except when changed by indiscretions on the part of the patient or trauma of mistreatment. In 70 per cent of the cases, complications are due to the latter factor. Throughout his book the author stresses the observation that severe gonorrhœa usually occurs in blondes.

The best prophylaxis against gonorrhœa is continence; after that the condom. Chemicals rank third, if used within the first 2 hours after exposure. Oral treatment alone is harmful because it creates latent infections. The best treatment consists of a bland chemical, preferably a 5 per cent silver nucleinate preceded by a potash wash (1:5000); both must be used very gently. The patient must be impressed with the fact that alcoholics and sexual excitement are tabooed and that there must be restriction of strenuous exercise. Foods make no difference in the course of gonorrhœa. One-fourth per cent protargol is the best drug for chronic cases. Early instrumentation should be avoided. Diathermy is of little or no value. Vaccines are of definite value if used in *very small* doses and at intervals of from 4 days to a week, using only 4 doses.

In posterior infections the slogan should be "no local treatment until the vesical symptoms have disappeared and the second urine is clear." Massage of the prostate gland should be done with gentle stroking parallel to the urethra. The midline should be stroked last. A nodular prostate should not be massaged until tuberculosis has been excluded.

Pelouze believes that epididymitis is produced by direct transference of infective material from the seminal vesicles down the vas, either from a full bladder plus sexual excitement or exertion, or from increased intra-urethral pressure of instrumentation.

Lymphocystic lesions of the posterior urethra have some relation to tuberculous foci in the body but are generally products of posterior infections. They are best treated by electrical fulguration or topical application of 50 per cent silver nitrate.

Evidences of gonorrhœal cure consist of no purulent urethral discharge; clean prostate, seminal vesicles, and Cowper's gland; no response to sounds or vaccines; and finally no recurrences from alcohol or coitus 3 months after stopping treatment. (Coitus is always done with condom during the 3 months.)

The appendage of case histories very clearly illustrates many errors in the diagnosis and treatment of urethral infections, but one cannot help but feel that the author has overdrawn this part of the picture.

The book is very instructive. It should be unusually interesting to those who treat numbers of gonorrhœa cases and should be read by those who treat any gonorrhœa at all. HARRY CULVER.

THE fifth edition of De Lee's *Principles and Practice of Obstetrics*[2] is a much handier volume than the previous editions. It is smaller in all dimensions yet it contains more pages. The printing, paper, and illustrations are of the highest quality. Both the text and illustrations have been carefully revised and a large number of new illustrations have been added.

The arrangement of the material is excellent both from the standpoint of the student and practitioner. The physiology of pregnancy, labor, and puerperium is first discussed. This is followed by the conduct

[1] GONOCOCCAL URETHRITIS IN THE MALE; FOR PRACTITIONERS. By P. S. Pelouze, M.D. Philadelphia and London: W. B. Saunders Company, 1928.

[2] THE PRINCIPLES AND PRACTICE OF OBSTETRICS. By Joseph B. DeLee, A.M., M.D., 5th ed. thoroughly rev. Philadelphia and London: W. B. Saunders Company, 1928.

of pregnancy and labor and then the pathology of all these is given in detail. Two sizes of type have been used, the larger size indicating the fundamental and more important matter and the smaller size the details of physiology, pathology, and of the various methods of treatment. The student thus has a textbook and a reference book in one volume.

It is noticeable that references to the literature are up to the minute; in fact, some of the books referred to were published only a few months before the appearance of this edition.

The chapters on the treatment of hyperemesis, eclampsia, abruptio placentæ, placenta prævia, rupture of the uterus, postpartum hæmorrhage, breech presentation, and the operation of forceps have been almost completely rewritten and the entire work has been greatly improved.

The author recommends low cervical cæsarean section instead of the classic section in all but exceptional cases. In the treatment of the lateral and central placenta prævia cases, he favors cæsarean section in most primiparæ when vaginal delivery promises to be tedious and difficult.

The chapters dealing with puerperal infection are particularly well written and an excellent, detailed discussion of the treatment of these cases is given. In the treatment of threatened abortion the use of castor oil is recommended. The reviewer cannot agree to this.

After a thorough reading of this work the reviewer feels that this volume is one of the bext textbooks on obstetrics on the American market.

EDWARD L. CORNELL.

IN the preface to *Clinical Medicine*,[1] Bethea states that his purpose in writing this book has been to "put into one volume of moderate size the latest and most generally accepted information as to the diagnosis and treatment of about one hundred of the most common diseases coming within the province of internal medicine." This has been done in order to meet the needs of the large group of practitioners who must carry on their work without the opportunities afforded by modern hospitals. The book is based on the lectures given by Bethea to undergraduate and postgraduate students during recent years at Tulane University.

The plan proposed has been faithfully followed and the author is to be congratulated upon having executed a work which is rich in practical information of a sort that is certain to be useful at the bedside. Much well deserved commendation may be given to this book. The clinical descriptions are concise and complete. The therapeutic sections are excellent and many practitioners, whether or not they belong to the groups to whom this work is especially directed, will find the discussions of treatment most useful.

Throughout the volume the endeavor for brevity has occasionally resulted in a terseness of expression which is almost harsh, but this rarely applies to the therapeutic sections. Again, it appears that the same emphasis upon short, direct, concise descriptions has led to occasional paragraphs of ambiguous meaning. For instance, the short section on auricular fibrillation leaves the impression that normal rhythm is frequently the result of digitalis medication and that quinidin is essentially interchangeable with digitalis in the treatment of this condition. Another edition might well include brief descriptions of the essential pathology of the various diseases, for this is, after all, the groundwork of diagnosis and treatment and one regrets the almost total omission of the pathological conditions underlying disease.

Though minor criticisms may be offered, this book ought to be a source of real help to many physicians who want to refresh their minds quickly concerning the important facts of diagnosis and treatment.

JAMES G. CARR.

[1] CLINICAL MEDICINE. By Oscar W. Bethea, M.D., Ph.G., F.C.S., F.A.C.P. Philadelphia and London: W. B. Saunders Company, 1928.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE CAUSES OF ANTE-NATAL, NATAL, AND NEO-NATAL MORTALITY OF INFANTS; WITH SPECIAL REFERENCE TO SOUTH INDIA. Being the Elizabeth Mathai Lectures Delivered Under the Auspices of the University of Madras at the Gifford School of Obstetrics. By A. Lakshmanaswami Mudaliar, B.A., M.D. Madras: Associated Printers, 1928.

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EUROPEAN CLINICS. Editorial Staff of European Clinics, 1927. Dr. William Lintz, Editor-in-Chief. Philadelphia and London: J. B. Lippincott Company, 1928.

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CONSECRATIO MEDICI AND OTHER PAPERS. By Harvey Cushing, M.D. Boston: Little, Brown, and Company, 1928.

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MAYO CLINIC MONOGRAPHS: THROMBO-ANGIITIS OBLITERANS; CLINICAL, PHYSIOLOGIC AND PATHOLOGIC STUDIES. By George E. Brown and Edgar V. Allen. Collaborating in Pathology with Howard R. Mahorner. Philadelphia and London: W. B. Saunders Company, 1928.

METHODS AND PROBLEMS OF MEDICAL EDUCATION. Eleventh series. New York: The Rockefeller Foundation, 1928.

DIABETIC SURGERY. By Leland S. McKittrick, M.D., F.A.C.S., and Howard F. Root, M.D. With a Foreword by Daniel F. Jones, M.D., and Elliott P. Joslin, M.D. Philadelphia: Lea & Febiger, 1928.

DIAGNOSTIC ET THÉRAPEUTIQUE PAR LE LIPIODOL; CLINIQUE ET RADIOLOGIE. By J. A. Sicard and J. Forestier. Paris: Masson et Cie, 1928.

LA TACTIQUE OPÉRATOIRE. Published under the direction of M. Robineau and W. M. Stern. Tactique Opératoire des Voies Biliaires. By W. M. Stern and R. Fourche. Paris: Gaston Doin et Cie, 1929.

LA PRATIQUE CHIRURGICALE ILLUSTRÉE. Edited by Victor Pauchet. Vol. xiii. Paris: Gaston Doin et Cie, 1929.

PRACTICE OF SURGERY; CLINICAL, DIAGNOSTIC, OPERATIVE, AND POSTOPERATIVE. Edited by Dean Lewis, M.D., Sc.D. Vol. i—Miscellaneous. Vols. x–xi—Gynæcology. Hagerstown, Maryland: W. F. Prior Company, Inc., 1928.

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TREATMENT OF VENEREAL DISEASE IN GENERAL PRACTICE. By E. T. Burke, D.S.O., M.B., Ch.B. (Glas.). New York and London: Oxford University Press, 1927.

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METHODS OF BIOLOGICAL ASSAY. By J. H. Burn, M.A., M.D. (Camb.). With an Introduction by H. H. Dale, C.B.E., Sec. R.S., M.D., F.R.C.P. New York and London: Oxford University Press, 1928.

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LEZIONI DI OSTETRICIA E DI CLINICA OSTETRICA. By Prof. Luigi Mangiagalli. Vol. i—Fisiologia Ostetrica; Gravidanza, Parto, Puerperio. Vol. ii—Operazioni Ostetriche. Milano: Soc. An. Instituto Editoriale Scientifico, 1928.

CHIRURGIE DES VOIES BILIARIES; SPIRO-CHOLÉCYSTOSTOMIE. By C. Sobre-Casas. Preface by Pr. J. L. Faure. Paris: Masson et Cie, 1928.

ANNALS OF ROENTGENOLOGY; Edited by James T. Case, M.D. Vol. v—Teeth and Jaws Roentgenologically Considered. By Herman A. Osgood, M.D. 2d ed. rev. New York: Paul B. Hoeber, Inc., 1929.

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AMERICAN COLLEGE OF SURGEONS

SOME THOUGHTS ON THE NATURE OF CANCER[1]

SIR CHARLES BALLANCE, K.C.M.G., C.B., M.V.O., LONDON, ENGLAND

THE International Conference on Cancer, which was held last July in London, evoked great interest. Scientists of all nations joined in the "great consult." They "thought nothing hard, much less to be despaired." The goal of effort was the discovery of the intimate nature of the disease and of the means for the prevention and cure of its lethal incidence on the human race.

When Homer told the story of Troy, he did not write prose or even history, he everywhere infused into it an incomparable ardor—he made an epic. An epic is a theme of action treated in heroic proportions and style. In our profession, the life enthusiasms and moral qualities of such men as Pasteur and Lister present to our minds epics of incomparable ardor. Their struggles were great, the issues were great, the men were great. It appears to me that the hopeful side of our labors is that some of our colleagues are approaching the subject of the cause of cancer in the epic spirit.

"The most important events of history are to the novelist what gigantic mountains are to the traveler. He surveys them, he skirts their base, he salutes them as he passes, but he does not climb them." In the same way I propose to survey, skirt, and salute some of the great landmarks in the research into the nature of cancer.

The chief papers and debates at the London Congress dealt with the early diagnosis, and the relative value of surgery and radiation in the treatment of carcinoma of the stomach, mamma, uterus, mouth and rectum, and of sarcoma of bone. There was also a short statement by Dr. Lumsden, concerning tumor immunity and vaccine treatment, but the debate which interested me most was that on the etiology of cancer.

The use of lead as a remedy did not obtain general acceptance. I do not object to a remedy because it is toxic. "No remedy is a practical remedy when the margin of safety between its lethal effects and its beneficial influence on the growth is less than that which admitted of reasonable control by the family doctor."

There was a general feeling that the rule persists that operation is essential in the treatment of cancer, but that operation combined with radium was, in certain cases, e. g., carcinoma of the mamma, of increasing value. For sarcoma of bone, in which amputation does but delay the fatal issue, some hopeful results were reported following the use of radium and toxins, or radium alone. The biological effects of radium and X-rays were discussed by experts.

When I was a house surgeon, it was generally thought that an attack of erysipelas after an operation for carcinoma mammæ had some effect in preventing the recurrence of the disease. I was in Berlin in 1884. Fehleisen was assistant to von Bergmann and he was infecting cases of carcinoma mammæ with the organism of erysipelas. The students nicknamed Fehleisen "erysipelas coccus." When the attack of erysipelas was severe the tumor might slough out. A death occurred and the treatment was stopped. Fehleisen was a forerunner of Dr. William B. Coley. This gives me the opportunity of paying a humble tribute to the transparent honesty and diligence of my friend Coley during a long period of years in his attack on the problem of cancer treatment. I have no doubt myself of the beneficial influence of the toxins in certain cases of cancer. The quality of honesty and straightforwardness is esteemed in my country and yours as a thing beyond price and of higher value than all the riches of the Orient. We are pilgrims of surgery who have reached only to the threshold of truth. In that pilgrimage, the name of Coley will ever hold an honored place.

Paracelus held that Nature was sufficient for the cure of most diseases; Art had only to interfere when the internal physician was tired and incapable. Then some remedy had to be introduced which should be antagonistic, not to the disease in a physical sense, but to the spiritual seed of the disease. I look forward to the time when our terribly mutilating operations for the cure of cancer, which must be performed at present, will be replaced by a vaccine or some such

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remedy which will be antagonistic to the spiritual seed of the disease.

Dr. Lumsden spoke of tumor immunity and vaccine treatment. He said that antibodies could be produced which had a specific affinity for cancer cells; they attacked and killed the cancer cells without damaging normal tissue cells. After the use of vaccine the immunity was much higher than otherwise. He suggested that those who were treating tumors with radium should not be in a great hurry to get rid of the local growth by sloughing, because this would prevent the increase of immunity.

It has long been known that most tumors in the commonly used experimental animals retrogress after a time, and that such animals are immune and cannot be further successfully grafted. Many years ago at the Buffalo Cancer Laboratory I saw mice who had in this manner become immune. This is not at all comparable to the retrogression of spontaneous tumors. Hence the same observation is rare in man. Many surgeons of much experience have observed the slow disappearance of a malignant tumor.

No one of us doubts the importance of the early diagnosis of malignant disease. But when a cancer gives a sign or a symptom, it is not in the early stage of growth. I have no faith in what has been termed the pre-cancerous stage: to me either a patient is suffering from malignant disease or he is not. I am all in favor of the intensive education of the family doctor concerning all newly discovered facts which may aid him in early diagnosis; but I am not in favor of lecturing to men and women of the lay public on a subject which they cannot in any measure understand, and which is with them ever associated with fear and dread. Fear and dread depress the resistance of the body cells and like injury may be the partial cause of the disease.

The debate in London on the early diagnosis of cancer of the stomach and on the value of excision of simple ulcer of the stomach as a preventive measure was of much interest. I would only add this: none of us is possessed of a knowledge which can allow him to state: this simple ulcer will become malignant. The prophet is a bad guide in surgery. Furthermore I am convinced of the immense value, in selected cases of simple ulcer of the stomach, of a posterior no-loop gastroenterostomy, the operation which we owe to your great surgeon, William J. Mayo.

In 1884 I joined the first class in bacteriology ever formed in the ancient University of Leipzig. The teacher's name was Becker, who was Koch's first assistant. The class was held daily for 6 weeks and was a great success. Becker insisted that Koch's four postulates must be fulfilled before any living organism could be held to be the cause of the disease. This is as true today as then.

My family had been decimated by malignant disease and as a student I had made up my mind, when opportunity offered, to work at its intimate pathology. When I returned to England I met the late Professor Shattock, who was a microscopist, and we started together on the great adventure.

Sir John Simon and Sir James Paget and other great pathologists of the mid-Victorian era had noticed the vital difference in activity of the normal and cancerous epithelial cell. Speaking generally the cancerous epithelial cell is indistinguishable anatomically from the normal epithelial cell, but its physiological life is different. The one has a normal life, but some profound change has happened to the cancer cell. It has become endowed with an immortal life and the property of endless growth.

In those early days it was suggested that some outside spermatic influence caused the change in the epithelial cell which gave to it an immortal life. Whatever takes place in our bodies has two distinct factors: the intrinsic factor which is the constitutional or resisting power of the cells affected, and the external injurious agent. The spermatozoon, meeting the right ovule, may create a life—a sort of other life or parabiosis.

I have always inclined to the belief that an external agent is the essential cause of carcinoma; that the infected epithelium is the habitat of the external agent, and that it will live and grow in none other.

In the carrying out of research on the intimate nature of any disease, it is essential to have an hypothesis of the nature of the disease in order to plan a scheme of work. The only scheme of work on the intimate nature of cancer which offers a prospect of success must be based on the hypothesis that some external agent is the essential cause. If it were possible, which it is not, it would be well if all our experimental work on the intimate nature of cancer could be carried out on carcinomata, since certain types of round cell sarcoma are not easy to distinguish microscopically from granulomata, while the microscopical appearances of the carcinomata are so definite that no mistake is likely to occur.

It is quite possible and indeed probable that the same external agent is the cause of both sarcoma and carcinoma. In the one case it finds a habitat in the mesoblastic cell, and in the other in the epiblastic or hypoblastic cell. Sir James Paget long ago pointed out that the same insect

produces different kinds of galls according to the different sites of oviposition.

The view that sarcoma and carcinoma have a common origin receives support from the tale of a case reported in 1926 in the *Annales d'Anatomie pathologique* by Lècase and Lecassaque.

In 1923, a woman was operated on for advanced carcinoma mammæ. Two weeks afterward, a student of medicine aged twenty-one, was told to remove by a syringe fluid collected under the scar. In doing so, a sudden movement of the patient caused the needle to be driven deeply into the palm of the hand of the student, and a small amount of the fluid in the syringe also entered the palm. Two years later there was a hard swelling with pain in the palm of the hand, and glands in the axilla were enlarged. A little later, several small tumors appeared in the forearm and arm, and amputation of the limb was performed. The beautiful illustrations accompanying the paper show clearly that the mammary tumor was a spheroidal-celled carcinoma, while the tumors which grew in the student's hand and arm were spindle-celled sarcomata.

COMPARISON WITH TUBERCULOSIS

When I was a student, anthrax was taken as the standard of comparison in pathological mycology. Let us take tuberculosis as the standard of comparison in the study of malignant disease. The late Dr. Bristowe compared cancer with other infective diseases, and stated that in his view every general specific disease begins as a local process. This is true of both tuberculosis and cancer. The clinical history of sarcoma or carcinoma is so closely akin to that of tuberculosis that it is quite within the truth to assert that there is no feature in the last named disease which is not paralleled in the others. Before 1881 the "authorities" regarded tuberculosis as a disease with many causes. Today some "authorities" regard cancer as a disease of many causes, and the specific organism remains undiscovered. But the analogy between tuberculosis and cancer is perfect, and repudiation of the analogy leads only to despondency and despair.

The endemic location of cancer comprehending sarcoma and carcinoma, about which much might be said, is a highly remarkable fact in the history of malignant tumors.

The phenomenon of atavism has been observed both in tuberculosis and cancer. "Parents seemingly healthy may beget a family of children who all die of phthisis. The taint is latent *in transitu*." It is within my knowledge that while the first and third generations of a particular family were devastated by cancer, the second wholly escaped. Paget wrote: "The tendency which exists in the parents may never become in him or her effective, although it may become effective in the offspring." These events appear to result from temporary impoverishment of the peculiar soil; or the atavism might depend, not on the subject, but on the parasite itself, the life of which might present an instance of alteration of generations. The phenomenon, indeed, may be comparable to that which necessitates in agriculture a rotation of crops.

In carcinoma the primary tumor is seated most frequently at sites where an infection from without would most readily take place. The metastasis by lymphatics or blood vessels in carcinoma or sarcoma is such as occurs in tuberculosis. It may be restricted to the lymph glands or be as widespread as a generalized tuberculosis (general sarcomatosis or carcinomatosis).

Even the glandular infection which occurs at times in tuberculosis without primary lesion has its counterpart in the squamous cell carcinoma of the inguinal glands in chimney-sweeps in whom there may be no discoverable primary growth. The latency of glandular infections is equally represented in tuberculosis and carcinoma. The sarcoma that grows at the end of a long bone after injury is comparable with the tuberculous osteitis existing under similar circumstances. Injury is the partial factor; the other factor in the case of tuberculosis osteitis we know to be a specific virus. The relation of injury to tumor growth is illustrated by the case of a patient who fell, striking the forehead against a sharp iron spike. The spike perforated the skull and brain. Death occurred 8 months later. The cause of death was angiosarcoma of the meninges and brain. The patient's brain would seem to have been inoculated at the time of injury with the virus of malignant disease as surely as a tube of culture medium is inoculated by plunging into it a platinum point deliberately charged with infective material.

Carcinoma has sometimes a purely local origin in the same way that a tuberculous infection may arise from direct inoculation. Take, for example, a case of squamous cell carcinoma of the lip. While still a local disease it may be completely eradicated. The case, in fact, is directly comparable to one of local tuberculosis from direct inoculation or to external anthrax which is still a local process, and might be termed one of local carcinomatosis. Local irritation and injury are sometimes spoken of as causes of cancer. But this is not so. The efficient cause lies beyond the irritation or injury which are but the partial causes of the disease. The injury prepares a nutrient soil favorable for the growth of the tubercle bacil-

lus or the effective agent of malignant disease. Hereditary predisposition or diathesis is nothing more than the presence in the body of a soil suitable for the growth and development of the virus.

Many examples of auto-inoculation have long been recognized, such as cœcal carcinoma, associated with numerous lesser growths in the colon, or an œsophageal carcinoma associated with several small growths below the primary tumor. These multiple small growths point to the possibility of an auto-inoculation of the same kind as occurs in tuberculous ulceration of the intestine. Such facts prove that the cancerous epithelium has been transferred as a graft, but it does not prove the presence of a parasitic virus. It proves only that the cancerous epithelium cell or the agent which made it cancerous is infective.

When tubercles spread through the body from a primary lesion, all the secondary lesions are typical of the disease, and contain the virus of it. The special anatomical characters of the secondary growths in carcinoma are ample proof of their source from the primary tumor. In sarcoma the best proof of the same fact is furnished by the melanotic variety where the pigmentation of the secondary tumors is sufficient evidence of their origin from the primary growth.

EXPERIMENTAL RESEARCH

After the rise of modern bacteriology, strenuous efforts were made to cultivate a specific microphyte from carcinoma. The results were uniformly negative. The failure of evidence in this direction led to the suggestion that the hypothetical microparasite might belong to the animal series, but the experiments in this direction were also negative.

How is the infection communicated to the epithelium if the carcinomatous parasite is a protozoon? How is the function of the first infected epithelial cell changed from a benign to a so-called malignant character? It may be in one or more of the following ways: (1) by absorption of a chemical product which is secreted by the parasite; (2) by the passage into the epithelial cell of the organism, the latter maintaining a separate existence in the former; (3) by the process of rejuvenescence in which the flagging life of a protozoon is revived by means of union with another.

What happens to the epithelial cell first infected?

Although single binary division is the chief mode of reproduction, another method of multiplication is by the nipping off, or budding, of spores from the parent cell. It is also not uncommon for a protozoon to break up into from 10 to 100 or more pieces or spores. Each piece contains all the elements of a perfect cell. If the carcinomatous cell has a similar life history, the pieces or spores of the subdivided epithelial cell may each grow into an adult carcinomatous cell, or may be thought of as conjugating with the surrounding normal epithelium, and of being the *fons et origo* in them of a carcinomatous rejuvenescence.

In sections of carcinoma there are certain appearances in the cells which were thought years ago to indicate the presence of a protozoon. I may cite the papers of Noeggerath, Soudakewitch, Foa, Ruffer, and Ludwig Pfeiffer. The opinion of Metchnikoff was that the appearances indicated nuclear degeneration. I do not know whether the virus of Gye belongs to the vegetable or animal kingdom, but if we suppose that it has its habitat in the nucleus of the cancer cell (and there are some reasons to think that this is so, though at present the optical difficulties of demonstrating it seem insurmountable), it is possible that some of the previous microscopical researches on the nucleus of the cancer cell may not have been all fruitless. Indeed it may be asked why should the nuclei of the actively growing cells at the periphery of a malignant growth show signs of degeneration?

The failure to transplant human carcinoma to the lower animals might be due to the fact that it is necessary for the parasite to assume a phase outside the human host in order to transmit the disease. This side of the problem has not been perhaps sufficiently explored. As germane to this point, Professor Shattock and I carried out a series of experiments with the object of seeing whether experimental infection could be brought about from the psorospermial bodies so common in the rabbit's liver. We were led to do this after Darier's description of the presence of psorospermia in the epidermis in Paget's disease of the nipple, and the alleged association of psorospermia with carcinoma in general. The experiments were performed upon rabbits, monkeys, dogs, and rats. The chief experiments were performed on rabbits as being most likely to receive infection. Intravenous and other methods of introducing the psorosperms were employed, but in no case was the animal infected. If the positive results attained do not prove the existence of an external agent, it must be borne in mind that the negative do not disprove it. They show only that the methods employed to demonstrate it were not suitable.

The method of transmission in infective diseases is not always so direct and simple as such grafting experiments pre-suppose. It has been shown, for example, that malaria cannot be transmitted

between birds by the injection of blood containing the hæmatozoon.

It has been shown that the capsule of an encapsulated protozoon consists at times of chitin or of cellulose. Both of these substances are absent from the tissues of vertebrates. Further pathogenic bacteria produce in cultures albumose. Neither chitin, cellulose, or albumose can be demonstrated in a carcinomatous tumor.

Though it has not been possible to transfer human carcinoma to the lower animals, it is well known that carcinoma can be transferred from animal to animal of the same species, and even from man to man. One of the best and earliest examples of transference from animal to animal was recorded by Hanau, who successfully engrafted squamous cell carcinoma from a rat into a series of other rats. In one experiment small portions of the tumor were placed in the abdominal cavity. Death ensued after three months and the abdominal cavity was found at the autopsy filled with nodules which presented the typical structure of squamous cell carcinoma. Dr. Hanau showed me microscopical sections of the growth which was placed in the peritoneal cavity and also sections from the growing nodules taken after death from the peritoneal cavity. All the microscopical sections showed a squamous cell carcinoma of the same type.

Since Hanau's experiment, numerous investigators have worked intensively on the intimate pathology of cancer, and the discovery of the filterable viruses has opened out wider fields of research.

In 1913 Fibiger published a report of research on cancer of the stomach in rats. He was the first to cause experimentally a malignant growth. The ingestion of cockroaches infected with a special spiroptera, or the ingestion of the nematode larvæ obtained from the muscles of the cockroach, produced squamous cell carcinoma in the cul-de-sac of the stomach. The eggs of the parasite were found free between the epithelial cells of the cancer. The cockroach is the intermediate host.

In London at the conference debate on the etiology of the disease the main discussion centered on the work of Rous, Borrel, Murphy, Gye, and Barnard and Leitch. Dr. Murphy said that now after many experiments the real nature of the cancer agent seemed to be emerging. He said that it was possible to extract with a considerable degree of regularity from the normal testes of the fowl a substance which, when injected into a normal fowl, would produce a malignant new-growth. Dr. Murphy's belief is that the external agent is an enzyme, not a virus. Professor Leitch supported the view of Dr. Murphy and stated that he had obtained a typical Rous sarcoma by the injection into a fowl of an extract of a normal fowl pancreas. The statements of Drs. Murphy and Leitch did not carry complete conviction to my mind. I am by no means convinced that the experiments of Murphy and Leitch constitute a final settlement of the work of Gye. Whether the causative agent is a virus as Gye maintains, or an enzyme as Murphy and Leitch hold, its most remarkable quality is its specificity in action. This specificity enables it to produce invariably the same type of tumor as that from which the agent was obtained. What does emerge is that the best workers in this field of pathology are agreed that there is an external agent concerned in the production of cancer.

Sir William Bragg, in his address last month to the British Association for the Advancement of Science, reminded his audience that in the nineteenth century light was regarded as a series of waves in an all pervading ether. This theory was based on profound mathematical analysis, and brilliant and far ranging observations. Sir William added that there is no question of its truth in the ordinary sense. But in the twentieth century a new field of optical research has been opened up, and has led to the inference that light has many of the properties of a stream of minute particles. This theory has passed the experimental test, and many experimental facts, inexplicable on the wave theory, are explained by the particulate theory. But how can anything be at once a wave and a particle? As yet there is no hint of reconciliation.

The dilemma is a rift in the whole fabric of scientific certainty. Is not the biologist in the study of the nature of cancer up against a dilemma which may be compared to that which now agitates the physicist? Virus or enzyme?—particle or wave? But there is hope of escape, as *The Times* suggested, for the scientific methods which have revealed it, are still only scratching the face of the unknown.

When bacteria were first recognized as the cause of disease, it was thought that their presence alone induced the disease. It was not till later that disease was discovered to be due to a specific chemical poison secreted by the bacteria. What is an enzyme? I do not know, but I do know that any active substance in the body, for example, a ferment, is manufactured by a living cell. This truth brings the virus and enzyme theories into close relation. Spontaneous generation being excluded, the crucial question is, what of the cell which manufactures the enzyme of Murphy?

I am indebted to Dr. Andrewes for permission to refer to his work. He has repeatedly precipitated vaccine lymph and the final extract remains effective in the production of vaccina. Dr. Andrewes states that the process can be repeated indefinitely. The research will be published in this month's number of the *Journal of Pathology and Bacteriology*. No one can suppose that the globulin precipitates are re-globulin, the cause of vaccina. It is clear that the virus has passed through all these stages of the purification of the original material, without losing its specific character. In the same way I suggest that the frequent precipitations employed by Murphy in the case of the extract of fowl testes, which he believes frees the resulting fluid from the virus of malignant disease, fails to do so. The reasonable conclusion is that the precipitated neo-protein carries the virus with it.

The fact that in certain cases the virus of fowl sarcoma is to be found in the testes of this creature presents little difficulty to my mind. It is only an interesting observation, for we know that the organisms of disease lie latent in our bodies. Otherwise, it would not be possible to explain after injury to the testicle or to a joint, the occurrence of tuberculous epididymitis or tuberculous arthritis.

The rare tumor chorionic carcinoma occurs in the uterus and occasionally in the fallopian tube and ovary. When the fallopian tube or ovary are affected, it may be presumed that these organs have been the seat of early ectopic gestation. The tumor occurs at any age within the limits of possible pregnancy. It would seem that the spermatozoon carried with it into the mature ovum not only its natural growth-producing power, but also the external agent of carcinoma. It is possible that the spermatozoon is the host of this agent, which is the essential cause of carcinoma. As germane to this view, it may be remembered that chorio-epitheliomatous elements are found in certain testicular tumors.

When I entered the profession the members of the Pathological Society of London were engaged at their meetings in showing specimens of disease obtained from the postmortem room. But the times were changing. The work of Pasteur and Lister had begun to permeate the profession. Anæsthesia had been discovered. Gross disease could be examined *in vivo* and not only on the postmortem table. The great age of dead meat pathology was passing away and in its place a living pathology was arising, the aim of which was the study and discovery of the intimate cause of disease.

I have already mentioned that as a working hypothesis in the search for the cause of cancer, I pin my belief to an external cause. In all diseases in which the pathological anatomist has the authoritative voice, intrinsic causes are sought after and extrinsic causes are relatively neglected. The idea of a specific extrinsic cause of any disease has owed its origin either to non-medical men like Pasteur or in later times to bacteriologists; pathological anatomists have never embraced the idea enthusiastically. Indeed they have generally resisted any encroachment from this direction upon their special domain. I remember the opposition of the great Virchow to the opinion that tuberculous disease owes its origin to a specific microbe; his opposition, in spite of his unrivalled authority—an authority no man could support now—was broken down because of the relatively simple and easily verifiable bacteriological findings of Koch. If the demonstration of the tubercle bacillus were entirely dependent upon animal experimentation of a complex character depending for interpretation upon acute insight into the pathological problem and upon scientific imagination in estimating probabilities, I doubt whether to this day the opposition, now proved to be reactionary, of the morbid anatomist would have entirely disappeared.

The nature of cancer appears to be so mysterious a problem, that perhaps we may say, with Shakespeare, of even the greatest mind in this field of experimental pathology that:

> "Something sure
> Hath puddled his clear spirit, and in such cases
> Men's natures wrangle with inferior things,
> Though great ones are their object."

For in 1880 I attended a lecture by Sir John Burdon Sanderson. The subject was the nature of scrofula. He described how he had gathered dust from St. Paul's Cathedral, from Westminster Abbey, and from his own drawing room, and how it had been placed under the skin of a series of guinea pigs. The result, we were told, was that all the guinea pigs were infected with scrofula, and that the disease could not be a specific one, as the specific agent could not be supposed to be in all these three places at the same time. I and my friends left the lecture theater feeling that the argument was not conclusive. The following year Koch demonstrated the tubercle bacillus.

In considering the problem of the cause of cancer, I am not disposed to attach great weight to the opinions of those who merely study appear-

ances of dead tissues under the microscope. I accept with due thanks their contribution toward the pathological definition of the fine structure of the cancer cell, but I am not prepared to be governed by their theories. It is to animal experimentation that we must look for the solution of this mysterious problem. The pioneers of cancer investigation—Jenson in Denmark, Borrel in France, and Loeb in America—confirmed the earlier studies of men like Hanau who had shown that animal cancer differs in no respect from human cancer and may be transmitted from animal to animal by the process of grafting. They showed, however, as the late Professor Shattock and I did, that all the cancers studied gave no evidence of a cause separable from the cell. The cell appeared to be the indivisible unit of the disease. These observations, confirmed by experimenters all over the world and especially on a large scale and with great exactitude by Bashford and Murray in London, gave no encouragement to those who believed in an extrinsic cause of the disease. Some were overwhelmed by the apparent completeness of the proof, or really by the absolutely negative character of all attempts to find an extrinsic cause. Even Borrel, one of the earliest and most energetic pioneers, and a believer in the microbic cause, was nearly swept under by the wave of confident dogmatism which teaches that the disease cancer is a cell in which nuclear degeneration independent of microbic activity has occurred. Borrel was never able to accept this sweeping conclusion and endeavored to resist orthodox opinion. He stood almost alone for a long time, neglected and powerless.

The tremendously strong dogmatic world-opinion is still uppermost, but not all-powerful. Murmurs of discontent with the stagnant stage of cancer research have been heard in every country. In England the formation of the British Empire Cancer Campaign owes its origin largely to the existence of the feeling that new blood was required to study afresh the origins of cancer. Doubtless in America you have felt somewhat similarly. This murmuring of opposition to the authority of the pathological anatomist has found expression in attempts to get behind the problem of cancerous growth by instituting departments of bio-physics, bio-chemistry, and so forth. But it is not very likely that the true solution of the problem will come from oblique investigations. The study of cancer must be direct. But since the investigations of Cancer Institutes have proved so barren in their negativeness, where shall we look for the lead in the great problem?

During the last three years there has been much discussion and more criticism of the researches of my countryman Gye. Now I should like to express my views on this matter. At once I must make it clear that I am not competent to discuss all the details of such work; I can give the reflections of one who has witnessed the fluctuations of medical opinion during fifty years, and has seen that which was abused accepted and proved true.

"Every discovery is a verified hypothesis; and there is no discovery until verification has been gained; up to that point it might be a guess, which might have been erroneous." Hence the incalculable value of the method of experiment.

"The wisdom of God receives small honor from those vulgar heads that rudely stare about and with a gross rusticity admire His Works. Those highly magnify Him, whose judicious enquiry into His acts and deliberate research into His creatures return the duty of a devout and learned admiration."

I can look back to a period of research beyond that which embraces the lives of most of my hearers. I have heard Virchow, Helmholz, and Ludwig lecture. I have seen Pasteur and Lister and Paget at work. I was a distressed and angry witness of the opposition and abuse which assailed Pasteur and Lister in the early days of their immortal labors.

The first point in Gye's work is this, that he sees the lead in cancer investigation to lie in the study of the remarkable group of fowl tumors which were first brought to light by Dr. Peyton Rous of the Rockefeller Institute. They are the exceptions in cancers in this, that they give evidence of a cause; and, as has happened so often, exceptions to general rules are likely to yield new knowledge which extends general laws. The work of Peyton Rous in proving the neoplastic nature of these fowl tumors has been properly acknowledged by Gye, who has sought to understand the nature of the cause of these tumors, and to link together the fowl and the mammalian tumors.

The essential claim which Gye makes is this, that the clear cell-free filtrate which is obtained by extracting a fowl tumor with saline, and which contains the tumor's cause, is not a simple single thing. The "agent" of the tumor is complex. Now the experiments which have been published in support of this contention have met with but little support. But if one takes into consideration the very, very delicate nature of the tumor agent, the fact, for example, that it disappears or becomes impotent after mere incubation at 37 degrees C. for a few hours and that it is demonstrable only with the highest power of the micro-

scope and with the use of ultra-violet light, itis easy to understand that the difficulties of the work are very considerable. Gye believes that the evidence he has adduced is good enough, at least as a first approximation to the truth, to show that the virus found in the fowl tumors is common to many animal and human tumors.

I cannot form a definite opinion upon all these technical matters but I have been for 50 years intensely interested in and have done a little work on the problem. I would put forward this point for your consideration. It is not sufficient for anybody who is deeply concerned with the cancer problem to be merely destructive in criticism; it is the duty of critics to find some other explanation of the peculiarities of the cancer problem if Gye's turns out to be wrong. At the present time, it is the only explanation which fits together a series of apparently irreconcilable observations.

"Truth is a golden thread, seen here and there
In small bright specks upon the visible side
Of our strange being's party-colored web.
How rich the converse! 'Tis a vein of ore
Emerging now and then on Earth's rude breast,
But flowing full below. Like islands set
At distant intervals on Ocean's face,
We see it on our course; but in the depths
The mystic colonnade unbroken keeps
Its faithful way, invisible but sure.
Oh, if it be so, wherefore do we men
Pass by so many marks, so little heeding?"